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Patent Interauricular Septum Associated with Mitral Stenosis: Lutembacher's Syndrome[1]

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TWO CASES studied in the Department of Radiology at Duke Hospital present such interesting and unusual roentgen features that they are reported here in some detail. Both are instances of a defective interauricular septum, associated with mitral stenosis, and the correlation between the resultant anatomical changes and the x-ray findings is noteworthy.

Patency of the interauricular septum is relatively common, but the co-existence of stenosis of the mitral valve is rare. The latter condition, though it presents a varied clinical picture, produces a roentgenogram which is characteristic; yet, unless the roentgenologist is aware of the syndrome, unfortunate misinterpretations are apt to ensue. A careful fluoroscopic study of the chest in which a "roentgenographic dissection" of the heart is accomplished will always help in clarifying the picture.

LITERATURE

There are 26 cases in the literature of co-existent mitral stenosis and patency of the interauricular septum. The first report was presented in 1865 by Martineau (1). Subsequently, several French investigators added to the list. Abbott (2) reported her cases in 1915, and one year later Lutembacher (3) produced a comprehensive survey of the condition. Since his contribution, the combination of lesions has been called Lutembacher's disease. Dressler and Rösler (4) in 1930 added a new case and discussed the roentgen findings. McGinn and White (5), in 1933, reviewed all the reported cases and recorded a case of their own. Since that time, Dr. Paul White (6) has studied another case which has not yet been published. Roesler (7) and Kirshbaum and Perlman (8) have recently written about the condition (1934 and 1939).

EMBRYOLOGY

The primitive atrium is at first a single chamber, but the topical modification into two portions is distinct very early. At the time that the single chamber is constricted by pressure from the developing bulbar limb of the primitive heart, the various septa are forming on the inner walls (9).

At first, there is a sickle-shaped fold formed along the anterior and posterior walls of the atrium; this is the septum primum. This septum grows downward from the posterior upper wall and finally reaches the opening from the atrium into the ventricular cavity. Its line of origin, however, gradually thins out as the edges thicken and there finally appears an opening at or near its origin, the foramen ovale. As this septum separates from its line of attachment on the posterior wall, another

[1] From the Department of Radiology, Duke University Hospital, Durham, N. C. Accepted for publication in May 1941.

leaflet, the septum secundum, appears to the right of it.

The two atria are now open by a wide communication. The final growth of the septa is as follows. Septum I, which has grown along the anterior wall and formed the foramen ovale at its original attachment posteriorly, now extends backward to the posterior and superior walls so that its free edge, directed toward the original foramen ovale, extends forward and downward over the upper wall; hence its free edge now faces backward and downward. The posterior part of septum I on the left has grown past the line of attachment of septum II, and the anterior prolongation of septum II has, on the right, grown past the line of attachment of septum I. Thus, there is left an oblique slit-like opening, the foramen ovale, between the septa. This opening ordinarily seals up by simple approximation of the two flaps.

The development is complicated and the question of the atrioventricular orifices has not been discussed; suffice it to say that the auricular septum does fuse with the endocardial cushions that participate in the development of the valves and it would seem possible that by improper fusion certain abnormalities in the atrioventricular valves might occur.

PATHOGENESIS

The intricate sequence of embryologic growth changes makes possible a variety of septal defects. Failure of normal progress of the septum primum results in a large defect of the lower portion of the septum, known as persistent ostium primum. Failure of the septum secundum to progress normally results in a deficiency in the upper anterior portion of the auricular septum, so-called persistent ostium secundum. Moreover, even though both septa develop, there may be failure of adherence of the flaps, so that the foramen ovale remains probe patent *via* an oblique passage between the leaflets.

In the fetus, a large proportion of the blood flows from the right auricle *via* the normal opening into the left auricle and thus to the left ventricle and out into the peripheral circulation. After birth, with the expansion of the lungs, the adult type of circulation is set in progress and, the auricular pressures being about equal, normal blood flow is maintained even though there be a partial defect in the septum.

If some change ensues, as mitral stenosis, the left auricular pressure rises and blood is forced from the left to the right auricle, with the result that the blood is sent through the pulmonary circuit a second time. The right side of the heart does more work than the left, and dilatation and hypertrophy of the right chambers take place, along with enlargement of the pulmonary artery and its branches. The left ventricle and aorta often remain small. In failure of the right ventricle, there is a further rise in right auricular pressure, which leads to a reversal of flow of blood from right to left. This, indeed, explains the occurrence of *cyanose tardive* found so often in patients with a deficiency of the auricular septum.

Firket (10) believed (1880) that the syndrome was due to a congenital malformation of the mitral valve and regarded the defective septum as a coincidence which permitted a shunting of blood and guarded against pulmonary congestion. Lutembacher believed that mitral stenosis led to an elevated pressure in the left auricle, which shunted the blood from left to right and thus prevented the foramen ovale from closing. Dressler and Rösler, with whom McGinn and White agree, claimed that elevation of left auricular pressure would favor closure of the normal slit-like opening between the auricular septa; they adhered to the idea that there exists, at first, a small patency in the septum and that stenosis of the mitral valve leads to stretching of the defect. White and McGinn point out that if the auricular patency and mitral stenosis were not primarily coincidental, then mitral stenosis would more often be complicated by open patency of the foramen ovale.

CLINICAL AND PATHOLOGICAL DATA

The majority of reported cases of coincidental patency of the interauricular septum and mitral stenosis have occurred in females, there being only 2 males in the complete series of 26. The combination must be considered as rare in view of the paucity of reports, although this may well be because the picture has rarely been recognized prior to postmortem examination.

Like many other congenital cardiac defects, the condition is reasonably compatible with fairly good health. Firket and Lutembacher reported patients who lived to seventy-four and sixty-one years, each of whom tolerated numerous pregnancies. McGinn and White report the findings in a male of fifty-six who enjoyed good health for all but the last four years of life. There are no particular physical characteristics, though the majority of those afflicted have been underdeveloped and subject to minor ailments. Some attribute the general underdevelopment to the relatively small aorta, which results in a lessened blood supply to the body.

There are no diagnostic physical findings. Shortness of breath on exertion has sometimes been present, but was never prominent until myocardial failure ensued. Cyanosis was not prominent in the reported cases except with the onset of failure. Clubbing has not been a presenting feature, having been reported once only. One of our patients complained chiefly of a cough and hoarseness and was referred to the hospital for treatment of a chronic pulmonary infection. Nor are the physical signs in any way characteristic. Most commonly found is a systolic murmur at the apex. In 8 of the cases reported, an apical diastolic murmur was heard. The pulse is usually of poor quality and in some instances has been irregular. Electrocardiograms in two cases showed right axis deviation.

At necropsy, the heart has invariably been large, primarily due to right-sided hypertrophy and dilatation. In 50 per cent of the cases, the pulmonary conus and arteries have been grossly dilated, whereas the aorta has been small. Many of the reported cases showed enlargement of the left auricle, but the left ventricle has been normal in size.

Fig. 1. Case 1: Accentuated right hilar shadow and enlargement of pulmonary conus and auricles.

The degree of patency of the septum has varied from small probe-patency to almost complete absence of a septum except for slight remnants of portions either of the septum primum or septum secundum.

CASE REPORTS

CASE 1: A. B., a white male, 15 years old, was admitted to the hospital Sept. 26, 1936, complaining of progressive weakness, dyspnea, and palpitation of four months' duration. The family and past histories were of no significance.

The patient was said by his family physician to have had heart disease at the age of six months. Throughout childhood he experienced exertional dyspnea and was unable to keep up with his playmates. He was able, however, to attend school and do light work on his parents' farm. During the past three or four months there had been an increase in dyspnea and orthopnea. On occasions, cyanosis had been observed. There was no history of fever, pain, chills, or edema. As far as is known, the patient had never had rheumatic fever, but upper respiratory infections had been frequent.

The patient was small for his age and undernourished. There was slight orthopnea, but no cyanosis. The temperature was 37.2° C., the pulse 96 and respirations 24. The blood pressure was 135/90. The eyes, ears, and nose were normal. The tonsils were chronically infected. The chest showed rachitic stigmata. The lungs were clear. There was vigorous precordial activity and the heart was enlarged to percussion; left border dullness, 8.5 cm. in

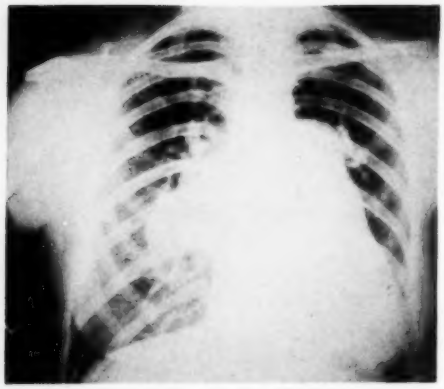

Fig. 2. Case 2: Note particularly the prominent hilar shadows, also the large conus. The heart is shifted slightly to the left.

fifth space, 9.5 cm. in fourth, 9 in third, 7.5 in second; right border dullness, 4.5 cm. in fourth space. The rhythm was normal. The sounds were loud, with a protodiastolic gallop over the second and third spaces to the left of the sternum. A loud, harsh, diastolic murmur was heard over the lower sternum. Abdominal examination showed the liver reaching 2 cm. below the costal margin and the spleen 3 cm. below.

Accessory clinical findings were: hemoglobin 16.4 grams or 105 per cent; red blood count 6,500,000; white blood count 9,700, with a normal differential count; Wassermann and Kahn reactions normal. The urine showed specific gravity of 1.024, albumin 3+, and an occasional hyaline cast. An electrocardiogram showed a rate of 91, P. R. interval of 0.16 sec., and marked right axis deviation. Blood cultures were negative.

On roentgen examination the heart was seen to be enlarged, with prominence of the pulmonary conus. The left auricle was slightly enlarged, as was the right. The lungs were clear.

CASE 2: J. H., a 34-year-old white female, was admitted to the hospital on Sept. 12, 1940, complaining of cough and hoarseness of about four years' duration. The family history was of no significance.

The past history disclosed one normal pregnancy fifteen years earlier. The patient had always experienced some fatigue on exertion and as a child had been unable to keep up with other children. A cardiac murmur was detected at the age of fourteen, prior to a tonsillectomy. There was a history of polyarthritis at the age of twenty-one.

The patient was relatively well and active until four years before admission. Following a slight upper respiratory infection, she coughed up small amounts of bright red blood. Three years later, she again coughed up a small amount of blood. The cough gradually increased. During the past two years, she had noted a gradual increase in exertional dyspnea and spent part of the time in bed. As the dyspnea gradually increased the cough became harassing and took on a brassy quality. Six months ago, the voice became husky and hoarse. About the same time, some cyanosis and slight clubbing of the fingers was observed. The patient was treated with potassium iodide and autogenous vaccines without improvement.

On examination the temperature was 38.6, respirations 22, and the pulse 100. The blood pressure was 120/80. The patient appeared well developed and nourished. There was a dusky cyanosis of the skin and mucous membranes. The fingers showed clubbing. The eyes were normal except for engorged retinal veins. The mouth and pharynx showed nothing unusual. Examination of the larynx showed paralysis of the left vocal cord, but no tumors or ulcers were seen. The neck veins were not enlarged. The heart was definitely enlarged and displaced slightly to the left, with the apical thrust in the fifth space, 9 cm. from the midsternal line. There was prominence to percussion over the left upper arc in the region of the conus and left auricle. The right border was slightly to the right of the sternum. There were an apical systolic thrill and a marked pulsation over the pulmonary conus. Auscultation revealed a loud reduplication of the first sound at the apex, followed by a soft systolic murmur. A low-pitched diastolic murmur was heard in the fourth space to the left of the sternum. P_2 was accentuated and there was a soft systolic murmur over the pulmonary area. The lungs showed exaggerated breath sounds over the right side, but no râles could be heard.

Accessory clinical findings were: hemoglobin 18.4 grams or 118 per cent; red cell count 5,880,000; white cell count 14,550. The urine was negative. Blood cultures were negative, as were Wassermann and Kahn reactions. An electrocardiogram showed sino-auricular tachycardia; rate 115, right axis deviation, P. R. interval 0.07 sec. *Diagnosis:* right axis deviation consistent with right ventricular hypertrophy.

ROENTGENOGRAPHIC FINDINGS

The syndrome described is characterized by a typical roentgenogram. The cardiac silhouette is enlarged to the right and left, with prominence of the pulmonary conus. The aortic shadow is usually normal or else actually smaller than normal. There is prominence of the hilar shadows, which are so striking, indeed, that they often resemble irregular lymph node masses. The left auricular border may be obscured by the bulging, dilated conus, but is often seen enlarged to the left.

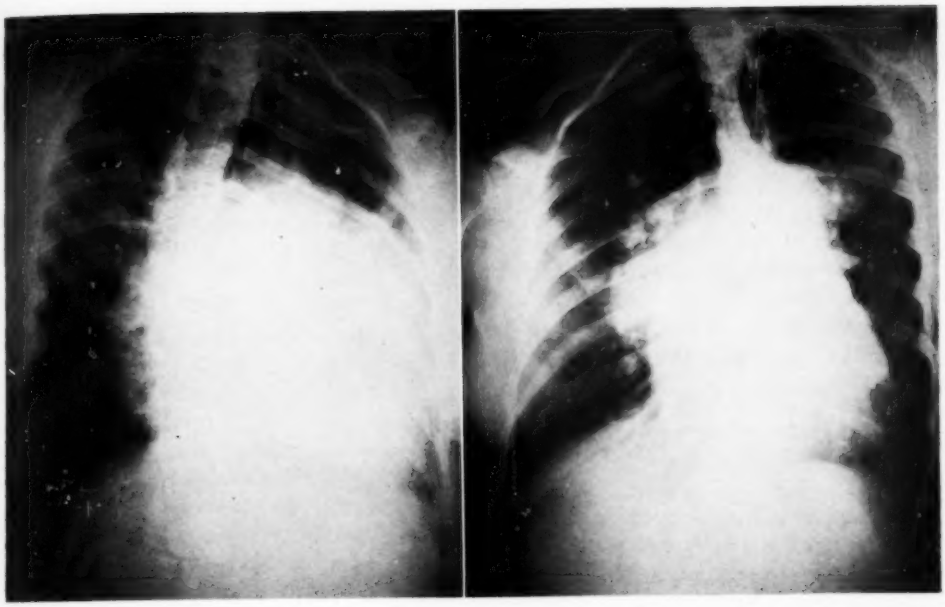

Fig. 3. Case 2: Right and left anterior oblique films to show the right-sided and left-sided enlargement.

The picture, though characteristic, is nevertheless confusing. The densities in the hila and conus regions have been unwittingly diagnosed as intrathoracic tumors, and on one or two occasions, patients have actually been subjected to exploratory operations. Fluoroscopy and oblique films will serve to clarify the changes observed in the conventional chest roentgenogram, and the anatomical relationships of the shadows can usually be readily established.

COMMENTS

The findings in the cases presented are typical and similar, but they vary in degree. The pulmonary conus in the first case is quite large and appears to obscure completely the left auricular border, and there is but moderate enlargement of the hilar shadows. The right-sided enlargement is quite prominent (Fig. 1). In the second case, the hilar shadows are striking. Moreover, the left auricular border is easily identified between the bulging conus and the left ventricular shadows (Fig. 2). Fluoroscopy revealed displacement of the esophagus so typical of left auricular enlargement and also established the increase in size of the right chambers. The "masses" in the hilar regions showed vigorous pulsations. Films taken in the left and right anterior oblique positions, and a lateral film, showed the changes in the cardiac chambers (Figs. 3 and 4).

Fig. 4. Case 2: Lateral film demonstrating well the changes in the pulmonary conus.

Neither case revealed any roentgenographic features of cardiac failure, nor was there clinical evidence. The severe symptoms in the second case were puzzling, but they are explained by a study of the roentgenograms. The direct pressure upon the left recurrent nerve by the conus produced paralysis of that nerve. There was also compression of the left bronchus, leading to decreased aeration of the left lung with resultant over-aeration on the right. This explains the slight shift of the heart to the left, and the polycythemia.

SUMMARY

1. Two cases of patent interauricular septum with mitral stenosis are presented.

2. The syndrome presents a characteristic roentgenographic picture, in which enlargement of the pulmonary conus and the hilar shadows predominate, along with right auricular hypertrophy.

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Clinical and Roentgen Manifestations of Carcinoma of the Duodenum[1]

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CARCINOMA OF the duodenum is a rare condition and therefore of unusual interest to the clinician and roentgenologist. In the past it was merely a pathological curiosity and until recent years there were no records of cases which were correctly diagnosed prior to operation. With the increasing number of cases recorded in the literature and the wider use of the roentgen method of diagnosis in lesions of the gastro-intestinal tract, it is hoped that a syndrome may be established which will make it possible to arrive at an early diagnosis of this disease on the basis of clinical observations and roentgenologic studies. With earlier diagnosis, operative treatment may in some instances be possible, whereas previously the disease has proved uniformly fatal.

In order to diagnose any of the less common conditions, three factors are essential. The observer must be thoroughly familiar with the manifestations on which the diagnosis may be based. Secondly, he must be able to differentiate the condition from other lesions which produce similar changes. Finally, he must bear the possibility of the disease in mind. It is important that rare lesions be recorded in the literature as they are discovered, in order to increase our knowledge of them.

INCIDENCE

Only three proved cases of carcinoma of the duodenum were found in the records of the Pondville Hospital. This institution, under the auspices of the Massachusetts Department of Public Health, is limited to the diagnosis and the treatment of growths of a malignant nature and has been functioning for the past twelve years. During its existence admissions have numbered about 16,000, not all of which were cases of cancer, and autopsies 1,655. This represents an incidence of 0.02 per cent of carcinoma of the duodenum. In Hinton's (1) series, the incidence was 0.03 per cent and other authors report it as high as 0.06 per cent. By way of comparison, the following figures are of interest, showing the incidence of carcinoma elsewhere in the gastro-intestinal tract, based on admissions to Pondville Hospital during this same period.

Carcinoma of the esophagus..	209 cases	(1.31%)
Carcinoma of the stomach....	442 cases	(2.76%)
Carcinoma of the small intestine.....	1 case	(0.006%)
Carcinoma of the colon.....	58 cases	(0.36%)
Carcinoma of the rectum and sigmoid.....	562 cases	(3.51%)

Carcinoma of the duodenum is essentially a disease of the later decades of life. In our series, the youngest patient was sixty-three years of age and the oldest eighty years, the average being seventy years. In the cases which we reviewed from the literature, the age limits extended from thirty-seven to eighty years, with an average of 48.3 years. This is in striking contrast to carcinoma of the stomach and colon, instances of which have been seen in patients as young as thirteen years of age.

There appears to be a definite preponderance of males, in the ratio of about two to one. This occurred both in our small series and in others reported in the literature. No reason for this is apparent.

PREDISPOSING FACTORS

We were unable to determine any constant predisposing factors for carcinoma of the duodenum. No relation to peptic

[1] From the Department of Roentgenology, Pondville Hospital, Massachusetts Department of Public Health, Wrentham, Mass. Accepted for publication in November 1940.

ulcer or any other lesion in the gastrointestinal tract is apparent. Nor were any nutritional, occupational, or hereditary factors demonstrable. The patients in our series did not present long-standing stomach or bowel complaints. The symptoms were usually of a few months' duration; in only one instance did the history extend over a period as long as two years.

PATHOLOGY

Carcinoma may arise in any portion of the duodenum. The second part shows the highest incidence, 62 per cent of the cases occurring in this region. The duodenal cap was involved in 25 per cent of all the cases studied. Thirteen per cent of the neoplasms were found in the third portion of the duodenum.

In about 90 per cent of the cases, the tumor was found to be adenocarcinoma arising from the mucosa. Scirrhous or colloid growths were the rule. Sarcomatous lesions were found in a very small proportion of the cases, from 2 to 5 per cent.

The gross findings were most frequently those of an annular, constricting neoplasm which in some instances completely encircled the lumen. This type was particularly prone to occur in the first and second portions. In the third part of the duodenum, the growth was more apt to be large and fungating. The sarcomas were usually softer and non-constricting.

Stenosis occurred relatively early and frequently in the lesions of the duodenal cap. In the neoplasms of the third part, obstruction was a late and common development.

Involvement of the ampulla of Vater is not common. Practically all the lesions involving the second portion of the duodenum, however, eventually caused obstruction of the bile ducts with resultant jaundice. It may at times be impossible to state with certainty whether the growth originated in the duodenum or in the ampulla itself.

Metastases were present in about 30 per cent of the cases. The regional lymph nodes were the most common site of metastatic involvement. In the far advanced cases, lesions were found in the liver, lungs, and bones. Metastasis took place late in the disease, indicating still more strongly the importance of early diagnosis.

One case is reported as having originated in a diverticulum. This is explained by the fact that the mucosa lining the diverticulum is usually the same as that in the duodenum itself.

SYMPTOMATOLOGY

The clinical symptomatology of carcinoma of the duodenum is indefinite, variable, and usually not pathognomonic. As a rule, the onset is gradual and insidious. Pain may be absent or slight. If present, it is located in the epigastrium or right upper quadrant. It is usually dull in character, although rarely it may be sharp and colicky. Weight loss is marked and rapid. When the lesion causes stenosis vomiting occurs. Blood and bile are frequently present in the vomitus along with undigested food particles. Anemia is usually severe. Jaundice occurs in about 20 per cent of the cases and may rarely be intermittent in character. Biliary colic may be present in the later stages of the disease.

The symptoms as a rule are of short duration, the length of time during which complaints are present averaging about four months. This is, of course, what would be expected because of the nature and situation of these growths. If the duodenum becomes completely blocked, the usual manifestations of obstruction dominate the picture. Similarly, invasion of the ampulla of Vater will produce the typical changes associated with jaundice.

The physical findings in the early stages are usually negative. As the growth progresses, the anemia and wasting characteristic of advanced carcinoma develop. A mass is palpable in the mid-epigastric region in about 50 per cent of the cases. In the later stages enlargement of the liver and an enlarged palpable gallbladder occur frequently.

Laboratory findings are variable and often of no assistance in arriving at a diagnosis. As a rule, increased hydrochloric acid is present in the gastric contents. Blood and bile are frequently found in the vomitus. The finding of blood on duodenal drainage with absence of bile is of special significance and indicates strongly the possibility of a neoplasm of the duodenum. Changed blood in the stools or tarry stools may occur. These findings, however, since they are present in so many conditions, are not particularly helpful.

ROENTGEN FINDINGS

Roentgen studies in the past have not given sufficiently definite or pathognomonic findings to permit of an accurate diagnosis or localization in many cases of duodenal carcinoma. The nature and location of the growth are such that this will doubtless continue to be true. It is hoped, however, that a review of the roentgen findings will assist in clarifying the picture so that earlier and more definite diagnosis may become possible.

In the earliest stages of disease there may be no demonstrable roentgen evidence. As the lesion grows, a disturbance of the mucosal pattern with thickening or absence of the rugae may be noted. Stout persons with rigid abdominal walls or those with very high, transverse stomachs may be difficult to palpate satisfactorily; in such patients these early changes may not be demonstrable. If the patient is thin, and compression of the duodenum can be carried out under fluoroscopic control, it may be possible to note these alterations quite early in the course of the disease. Filling defects occur as the lesion enlarges. If there is localized ulceration within the neoplasm, flecks of barium may be retained in the ulcer crater. Ulcerative lesions in the distal portions of the duodenum and unusually large ulcers of the cap, particularly those which continue to enlarge despite adequate dietetic and medical therapy, must be viewed with suspicion.

Few patients present themselves for study in the early stages of the disease, the majority being first seen with extensive growths or in the stage of obstruction. In these later, more advanced cases, one or more of the following findings may be observed: narrowing of the duodenum; canalization of the lumen; rigidity of the duodenal cap; diminution or absence of the normal markings. With stenosis of the second or third portions, the duodenal loop becomes widened and may present a wide curve to the right and downward. The second portion of the duodenum may be displaced medially. Pressure defects may be present, with flattening of the duodenal cap, narrowing of the pylorus and antrum of the stomach, and displacement of the stomach upward and laterally. Growths in the third portion of the duodenum are apt to be large and bulky with resultant extensive defects. When obstruction occurs, the stomach, pylorus, and proximal portions of the duodenum become dilated; gastric peristalsis is deep and vigorous, alternating with periods of absent activity; reverse peristalsis may be present. Six-hour, twenty-four-hour, and forty-eight-hour retention may occur in the stomach. The presence of air in the bile ducts has been recorded in one instance. Obstruction of the common bile ducts as demonstrated by opaque oil injection (cholangiography) has also been described.

It will be seen that the roentgen manifestations of carcinoma of the duodenum are variable, being dependent on the location of the growth, the size of the lesion, the presence of obstruction, and other factors which happen to be present in the individual case. Since early diagnosis is of such great importance, the slight variations which occur in the first stages of the disease must be sought for carefully. If suspicious changes are noted, the patient must be re-examined at intervals in an attempt to establish the diagnosis as early and as definitely as possible.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of carcinoma of the duodenum presents especial difficul-

ties, since many other conditions give strikingly similar appearances. In some cases, careful studies will enable one to arrive at the correct diagnosis; in others it may be impossible to exclude certain conditions with certainty.

Benign tumors of the duodenum, such as polyps, have smooth, regular contours and the duodenal walls remain flexible and normal in size. These neoplasms rarely, if ever, cause obstruction or bleeding. A polyp may have a long pedicle and be freely movable, appearing in somewhat varying locations at different times. On re-examination benign tumors show little if any change in size and contour.

Carcinoma of the bile ducts or ampulla of Vater with invasion of the duodenum may present appearances identical with primary carcinoma of the duodenum and cannot be differentiated from it. Cancer of the head and body of the pancreas may cause narrowing and displacement of the duodenum with widening of the duodenal loop. Filling defects and irregularity of outline are usually not present and the mucosal pattern is preserved. Obstruction does not occur as a rule in lesions of the pancreas.

Lymphoblastoma and lymphosarcoma usually cause large, mottled defects with marked irregularity of outline. Simultaneous lesions of the lymphoid structures in various parts of the body and enlargement of the spleen are frequently present. The rate of growth is much more rapid, as demonstrated by periodic re-examination, than in carcinoma. The response to deep roentgen therapy is prompt and marked in the lymphoid lesions, and the test of radiation therapy is often of great value in diagnosis.

Carcinoma of the stomach, particularly in the region of the pylorus, may on occasion offer some difficulty in diagnosis. The roentgen studies will, however, demonstrate that the lesion is proximal to the pyloric sphincter rather than in the duodenum. The absence of free hydrochloric acid in the stomach in gastric neoplasms is also of importance.

Adhesions about the duodenum either postoperative or as a sequel to pericholecystitis may cause narrowing, distortion, and angulation of the duodenum. The duodenal mucosal pattern is distorted but not absent; fixation of the first and second portions of the duodenum may occur along the inferior surface of the liver; obstruction is rare with adhesions.

Diverticulum of the duodenum presents a pouch-like projection from the lumen of the duodenum rather than constriction or obstruction as in carcinoma. It must be borne in mind, however, that a neoplasm may originate within a diverticulum. Food residue in a diverticulum produces a mottled, irregular appearance closely simulating a new growth. Re-examination after an interval of a few days will usually demonstrate a marked alteration if not total disappearance of the questionable shadows resulting from food particles.

Scarring from an old healed duodenal ulcer is usually associated with a previous history of ulcer; no mass is palpable; the hydrochloric acid in the stomach is normal or increased. In ulcer, there is no loss of weight and there is a history of intermittent activity, while in carcinoma the symptoms are continuous and usually rapidly progressive.

Duodenal obstruction may also result from external pressure, among the chief causes of which are enlargement of the gallbladder; tumors of the omentum, pancreas, liver or kidney; enlarged retroperitoneal nodes and other masses in this region; aneurysms of the celiac axis at the hepatic artery; pressure from the superior mesenteric vessels. If the stenosis is partial or intermittent, differentiation may be possible. With complete obstruction, however, the cause of the stenosis can rarely be determined.

In acute or chronic pancreatitis, there is no change in the gastric acidity, blood is not present in the vomitus or stools, and the pain, which is an outstanding complaint, is acute and severe.

Impaction of a gallstone in the duodenum is a rare occurrence, yet it may

cause confusion in diagnosis. If the stone does not cause complete obstruction, the smooth, round borders will suggest a polyp rather than a malignant neoplasm. With complete blockage of the lumen of the intestine by calculus, the sharp, rounded superior margins of the stone should suggest the correct diagnosis. Films of the abdomen prior to the administration of the opaque meal may reveal the stone if it contains sufficient calcium to cast a shadow.

TREATMENT

Medical therapy is of value as a supportive measure in malignant neoplasms of the duodenum. With dehydration the administration of fluids orally or by injection methods is indicated. Anemia and vitamin lack must be prevented or treated if present. Transfusions are given as necessary. Surgical relief may be impossible even in the first stages of the disease because of the location of the primary growth. Nevertheless, the importance of early diagnosis cannot be stressed too strongly as the only hope of relief lies in prompt operative intervention. Exploratory laparotomy is indicated if the roentgen evidence points strongly to a duodenal neoplasm. If intervention is delayed until the diagnosis has been established with certainty, it will doubtless be too late to effect a cure.

Palliative surgery, such as partial resection or short-circuiting maneuvers for the relief of obstruction, should be resorted to as necessary and serve to diminish suffering and may prolong life. Roentgen and radium therapy offer little, because of the location of the growth. Radiation may, however, be of value as a palliative measure and in differentiating lymphosarcoma, which responds promptly and markedly to radiotherapy.

PROGNOSIS

The prognosis in carcinoma of the duodenum is poor. The average duration of life is six to eight months. The longest period of survival is about two years. Operative procedures, while of importance for palliation, do not in the cases reported appear to have had any great effect with reference to the prolongation of life.

Fig. 1. Case 1: Carcinoma of the duodenum. The first portion of the duodenum is markedly contracted and constantly irregular in outline. There is no obstruction.

CASE REPORTS

CASE 1 (Pondville Hospital No. 111): A. S., male, white, aged 64 years, entered the hospital complaining of pain in the epigastrium, of two years' duration. The distress usually came shortly before eating and was referred to the mid-epigastric region. It frequently awakened the patient at night. Sodium bicarbonate or crackers and milk afforded relief; exercise, such as walking, increased the discomfort. For periods of two to three weeks' duration there was complete freedom from complaints.

About six months before admission the patient noticed tarry stools on several occasions. At about that time he had a severe rectal hemorrhage, which caused weakness necessitating bed rest for a period of several days. He had since suffered almost constantly from a severe burning sensation in the right lower quadrant. There had been no nausea or vomiting and the appetite was good until recently. During the month prior to admission to the hospital there was a loss of about 30 pounds in weight.

The appearance was that of a cachectic, anemic old man. There were no palpable masses in the abdomen and no abnormal findings in the chest. The red blood count was 1,690,000; hemoglobin 20 per cent; moderate achromia. The Wassermann test was negative. On roentgen examination, the stomach and esophagus appeared normal. The

Fig. 2. Carcinoma of the dudoenum. The lesion involves the third portion of the duodenum. The duodenum proximal to the neoplasm is greatly dilated and there is partial obstruction.

duodenum showed an extensive irregularity, which appeared ulcerative in character, involving the first portion or duodenal cap. There was no six-hour gastric residue.

The day following admission, the patient vomited a large amount of brownish fluid and appeared to be bleeding internally. Transfusion was performed, but the condition became rapidly worse and death occurred.

Postmortem studies revealed an ulcerative lesion, 4 cm. in diameter, involving the first portion of the duodenum. This proved on microscopic study to be adenocarcinoma.

CASE 2 (Pondville Hospital No. 1,567): K. W. K., female, white, aged 70 years, had been suffering for about two years from anorexia and occasional nausea and vomiting. Jaundice gradually developed and had increased markedly during the past two weeks. There had been no gastro-intestinal complaints prior to the onset of this illness.

The patient grew rapidly weaker and took very little nourishment or fluid. No masses were present in the abdomen and there was no tenderness on palpation. She refused any operative procedures and died of progressive weakness and inanition.

Postmortem studies revealed a large, papillary adenocarcinoma in the region of the ampulla of Vater. The lesion measured about 3 × 2.5 cm. The common bile duct was almost completely obstructed by the growth. There was an associated generalized jaundice and hemorrhagic diathesis with extensive metastases in the pancreas, para-aortic lymph nodes, and the lungs.

CASE 3 (Pondville Hospital No. 16,472): C. H. L., white male, aged 80 years, complained of mild epigastric pain of three or four months' duration, with frequent short attacks of cramp-like abdominal pain accompanied by diarrhea. After the subsidence of the acute attacks there was increasing constipation. Tarry stools occurred on several occasions. There had been a weight loss of 35 pounds during the past year, with marked diminution of strength and vitality.

The patient was emaciated, with a large liver palpable three finger-breadths below the costal margin. No other abdominal masses were felt. The lungs were clear. The heart was enlarged. There was a severe anemia. The Hinton test was negative.

The day following admission to the hospital, the patient fell while attempting to get out of bed and died a short time later.

Postmortem studies revealed a dilated esophagus and stomach which contained partially digested food. The proximal two-thirds of the duodenum were dilated. A large, firm annular neoplasm encircled the entire third portion and diminished its lumen to about one-third of its normal diameter. The surface of the lesion was cauliflower-like and projected intó the lumen. The microscopic diagnosis was adenocarcinoma of the duodenum. The immediate cause of death appeared to be a pulmonary embolus secondary to chronic myocarditis.

SUMMARY AND CONCLUSIONS

Carcinoma of the duodenum is a rare condition. It may occur in any part of the duodenum but is most common in the second portion.

The clinical symptomatology, physical findings, and laboratory studies are indefinite and variable.

Roentgen studies may show a filling defect, narrowing of the duodenum, and obstruction. The roentgen manifestations vary with the location of the growth, the size of the lesion, the degree of stenosis, and other important factors.

Medical therapy is supportive in nature.

Surgery may offer hope of a cure only if the condition is diagnosed early and the growth is in a portion of the duodenum which is resectable.

Palliative surgical procedures include partial resections or short-circuiting maneuvers for the relief of obstruction.

Radiation therapy offers little in this condition because of the location of the growth.

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Phytobezoar and Its Formation in Vitro[1]

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NUMEROUS CASE reports of phytobezoar —gastric concrement of vegetable origin—were published in the medical literature of the past decade, evidently inspired by the work of Hart (10) and Maes (17). In 1930 Kerr and Rypins (14) were able to collect only 20 cases from the literature, but at the end of 1939 De Bakey and Ochsner (6) found 119 cases recorded and added 7 of their own. Probably not more than five or ten case reports have appeared in the international medical literature since. Most of these publications appeared in American medical journals, but cases have been reported, also, in the Canadian, English, German, Hungarian, Italian, and Japanese literature.

Most of the phytobezoars—probably 90 per cent of them—are of persimmon origin. A few cases have been caused by prune and raisin seeds and skin, and by celery and salsify fibers, and at least one case due to pumpkin (1) and one due to peaches are on record.

The majority of the cases reported from the United States occurred in the so-called "persimmon belt," of the South, Middle West, and Southwest, with Kansas, Oklahoma, and Texas as the western boundaries. All three species of persimmon—*Dyospiros virginiana*, *texana*, and *kaki* (Japanese)—are bezoar forming.

Though the number of recorded cases is still limited, persimmon bezoars are not rare in the "persimmon belt." Probably Murdock's (19) paper indicates the true number of cases diagnosed. He reported 16 cases but only one of them was his own observation; the remaining 15 cases he collected from his fellow physicians around Tulsa, Oklahoma. Outside the "persimmon belt," on the other hand, this condition is extremely rare. Feldman (9) of Baltimore has observed none among 30,000 roentgenologic examinations of the gastrointestinal tract. The writer, while resident in Radiology at Saint Luke's Hospital, New York City, reviewed over 6,000 gastric cases studied roentgenologically and found no phytobezoar on record.

A review of the literature reveals rather uniform case reports with excellent descriptions of clinical, roentgenologic, and operative findings. Laboratory data are lacking in approximately 80 per cent of the cases. We were able to find only 22 cases for which the gastric analysis was stated.

Although the clinical symptoms, which are those of a more or less severe gastritis, sometimes of ulcer, or even of cancer, if associated with a positive history of persimmon intake might be suggestive of a phytobezoar, a reliable diagnosis can be made only by roentgen examination. Fluoroscopy of the stomach with barium meal reveals a single or sometimes multiple central filling defect, usually freely movable on manipulation. It is advisable here, as well as in any other condition of the stomach, to start fluoroscopy with a moderate amount of barium; otherwise, the excess of opaque material may obliterate a bezoar of comparatively small size, as is demonstrated in Figure 5. Sometimes a bezoar coated with a thin layer of barium is well visualized on the five-hour or even the twenty-four-hour plate (Fig. 3). Two of our nine cases showed this phenomenon.

In the majority of cases only one bezoar was found at operation or roentgen examination. Double gastroliths were reported by Droegemuller (7), Outten (20), Rodgers (24), Thorek and Rutter (28). In Wyatt's (29) case there were three bezoars, and Fallis (8) found a large one accompanied by several small ones. In our series of 9 cases, there were seven

[1] From Department of Radiology, University of Oklahoma Hospital; John E. Heatley, M.D., F.A.C.R., Director. Accepted for publication in April 1941.

single gastroliths; one was double, and in one case a large bezoar was surrounded by several smaller ones.

The incidence of gastric ulcer is very high in these cases. De Bakey and Ochsner (6) in their thorough review found it to be present in 24.4 per cent. Satterfield (26) has seen three ulcers in a single case. This complication was more common in our series. Seven of our 9 patients (77.8 per cent) had gastric ulcer; two ulcers were ruptured at admission and two others showed signs of severe bleeding. One of the bleeding ulcers also was ruptured and healed spontaneously, probably before admission, as it was revealed at autopsy.

Phytobezoars in contrast to trichobezoars (hair balls) are more common in males than in females. Only 3 of the 22 cases which we reviewed from the literature were in females. Our own experience substantiates this observation, as only two of our nine patients were women. The age incidence follows very closely that of cancer, being highest in the fourth, fifth, and sixth decades. Only a few of the recorded cases occurred in children. Most of the cases listed in the literature occurred in the white and yellow races. Three cases in Negroes are on record.

The etiology of bezoar formation is not yet known. Every year tens of thousands eat persimmons, and the main consumers—children and colored people—are immune to almost a hundred per cent. Both hypoacidity and hyperacidity have been considered as causative factors, but there are no analytical or experimental data to support these views.

In observing a series of 9 cases of persimmon bezoars—probably the largest group published from one institution—we became interested in the chemical factors involved in bezoar formation. Our study is based on 22 examples from the literature in which the gastric analysis is stated, together with 4 of our own cases for which we had complete laboratory data. When the 26 cases were tabulated (Table I), it was seen that free hydrochloric acid was absent in only 2 patients; 2 showed hypoacidity and 22 (84.8 per cent) normal acidity or hyperacidity. In other words, 92.4 per cent had free hydrochloric acid. The 2 patients with no free hydrochloric acid were from our own series, and we carefully examined their case reports, roentgen findings, and all other data for some possible connection between the anacidity and bezoar formation. In one of the cases (Case 3) two moderately large bezoars were found, and in the other (Case 4) operation disclosed an unusually large impacted gastrolith. We believe that in these two cases a moderate amount of acid was probably secreted, but was absorbed by the large bezoars or, since the gastroliths were situated quite high in the stomach (Figs. 1 and 2), that the Ewald meal, or that part of it which was withdrawn, could not mix with the gastric juice. The laboratory reports of the 26 cases strongly suggest a governing rôle of the gastric acid in phytobezoar formation.

For the verification of this hypothesis we investigated the behavior of persimmons, prunes, raisins, and celery in various solutions of decinormal hydrochloric acid with and without pepsin. Alkaline solutions of various strengths and water were used as controls. The experiment with the persimmon fruits was divided into two groups: in group A fruits not completely ripe but edible, picked before the first autumnal frost, were used; in group B the fruits were completely ripe, picked after frost. The prunes, raisins, and celery were ripe, as those which are used for everyday consumption.

In order to obtain similarity to physiological digestion, all fruits were well masticated and mixed with saliva; they were then placed, without skin and seeds, in five test tubes containing 0.1, 0.2, 0.4, 0.6, and 0.8 per cent solution of decinormal hydrochloric acid, respectively. A second row of five test tubes contained fruits with skin, and a third row fruits with skin and seeds, all in decinormal hydrochloric acid as in the first row. The fruits in rows 4, 5, and 6 were identical with those of rows 1, 2, and 3, but the hydrochloric acid solu-

TABLE I: GASTRIC ANALYSIS IN 26 CASES OF PHYTOBEZOAR

No.	Author	Age	Sex	Total Acid	Free HCl	Blood in Stomach	Blood in Feces	Red Blood Cells	Hgb., %	White Blood Cells	Polys., %	Remarks
1	Allen (2)	71	M	40	27	+	+	3,980,000	..	12,500	83	.....
2	Balfour and Good (3)	24	M	66	42	..	..	Normal	66	Normal	..	Ulcer
3	Camp (4)	48	M	60	40	..	..	Normal	..	Normal	..	Ulcer
4	Chont	65	M	52	23	+	+	2,880,000	47	9,900	89	Ulcer
5	Chont	45	M	37	0	+	+	4,950,000	95	14,450	84	Ulcer, 2 bezoars
6	Chont	39	M	46	0	−	−	4,800,000	85	10,150	76	.....
7	Chont	66	M	97	75	..	..	4,520,000	86	6,500	67	Ulcer
8	David (5)	59	F	22	11	−	−	2,650,000	..	10,500	..	.....
9	De Bakey and Ochsner (6)	59	M	60	40	..	..	4,880,000	80	12,000	70	..... Two bezoars
10	Droegemuller (7)	37	M	32	16	..	..	.....	..	.....	..	Ulcer, 2 bezoars
11	Hart (10)	35	M	74	92	+	..	.....	..	.....	..	.....
12	Hart (10)	38	M	112	40	..	..	.....	..	.....	..	Ulcer
13	Judd (13)	28	M	48	27	..	..	4,490,000	..	.....	..	.....
14	Larimore (15)	20	M	56	36	..	..	.....	..	.....	..	.....
15	Larimore (15)	46	F	72	20	..	..	4,536,000	..	6,760	..	.....
16	Lyons and Cody (16)	37	M	28	28	+	+	.....	..	.....	..	.....
17	Lyons and Cody (16)	42	M	38	30	−	−	5,100,000	..	12,200	62	.....
18	Lyons and Cody (16)	41	M	44	42	+	..	3,700,000	..	7,500	..	.....
19	Moersch and Walters (18)	49	M	56	30	..	..	.....	..	.....	..	.....
20	Pollok (21)	72	M	44	50	..	..	4,680,000	..	12,800	70	Ulcer
21	Porter and McKinney (22)	35	M	80	47	..	..	3,320,000	..	8,000	..	.....
22	Potter (23)	57	M	64	48	..	..	.....	..	.....	..	Ulcer
23	Rodgers (24)	59	M	56	60	..	..	Normal	..	Normal	..	Two bezoars
24	Ruffin and Reeves (25)	52	M	...	75	..	..	4,200,000	..	.....	..	.....
25	Schulze (27)	52	M	96	19	+	..	.....	..	.....	..	Ulcer
26	Thorek and Rutter (28)	54	F	37	..	−	−	4,300,000	..	5,600	..	Two bezoars

tion contained pepsin. The seventh row contained fruits with skin and seeds in four different solutions of sodium bicarbonate; the fifth test tube of this row contained water.

For the celery and raisin experiments three rows of five test tubes were used. The first row contained the whole specimen in decinormal hydrochloric acid solution of the strengths described above; the solution of the second row contained pepsin in addition to hydrochloric acid, and the third row served as a control.

This experiment disclosed that neither prunes, raisins, celery, nor completely ripe persimmons form bezoars *in vitro*. Incompletely ripe persimmons, however, form bezoars in any solution of decinormal hydrochloric acid, with or without pepsin, but not in water or alkaline solutions. Bezoar formation, that is, the solidification of the unripe fruit, started within twenty-four hours in the weaker solution. In the stronger solutions of hydrochloric acid the formation of bezoar was delayed to forty-eight hours.

After the completion of our experiment we were informed by Dr. M. R. Everett, Professor of Biochemistry, University of Oklahoma Medical School, that Izumi and his co-workers (11 and 12) had published an article on this subject, but we have not been able to ascertain the details of their work from the two short abstracts available. No claim is made for originality on our part. We simply became interested in the chemical factors involved in phytobezoar formation after having observed a series of 9 cases of persimmon origin.

CASE REPORTS

CASE 1 (No. 60,427): F. B., a white farmer, aged 28, entered University Hospital on Jan. 16, 1932, complaining of extreme abdominal pain and cramps. On Nov. 20, 1931, he had eaten some persimmons and the next day experienced pain and

burning in the epigastrium, which later spread over the entire abdomen. He vomited a clear, watery fluid occasionally, and had to take either an enema or "strong pills" daily, although he had never before been troubled with constipation. Belching was frequent, and there had been a loss in weight of 40 to 50 pounds in two months.

At admission the patient was vomiting almost continuously material which had a fecal odor and taste. His case had been diagnosed at home as gall-bladder disease and by another physician as inflammation of the bowel. The family and past histories were irrelevant.

Examination revealed a tender, somewhat symmetrically distended abdomen with muscular rigidity. The temperature was 99.8°, pulse 102, and blood pressure 130/85. Red blood cells numbered 5,060,000; hemoglobin 86 per cent; white blood cells 7,850, with 90 per cent polymorphonuclears. The vomitus was dark brown and thick. Microscopically it was found to contain a few red and white blood cells, slight mucus, and heavy amorphous material.

At operation a large perforated ulcer was found on the lesser curvature, about 6 cm. from the pyloric ring, with indurated borders through which a gallon or more of bile-stained fluid exuded on manipulation. The ulcer was cauterized and sutured, and the abdomen drained. Death occurred on the thirteenth postoperative day from myocardial failure. Necropsy revealed a generalized peritonitis, and in the stomach a crescent-shaped, freely movable black mass, measuring 4.5 × 2 inches, composed of persimmons.

CASE 2 (No. 92,042): J. M. H., aged 65, a white farmer, ate a number of persimmons about the middle of November 1936. He immediately began to experience epigastric pain, which continued until admission to the hospital on June 5, 1937. Pain usually came on one to two hours after meals or during the night and was relieved by a small amount of food. Appetite was good, but was satisfied by an unusually small quantity of food. Belching was frequent, and there had been a loss of about 30 to 40 pounds in weight. Constipation was rather severe, and stools were dark in color. Nausea was present much of the time, but vomiting occurred only occasionally. For three weeks previous to admission pain had been very severe.

Examination revealed tenderness over the left upper quadrant. The blood count showed red blood cells 2,880,000; hemoglobin 47 per cent; white blood cells 9,900, with 89 per cent polymorphonuclears. Gastric analysis showed free hydrochloric acid 23, and total acid 52. Roentgen examination revealed a freely movable, ball-shaped mass in the stomach and an ulcer niche on the lesser curvature near the pylorus.

On operation a black, freely movable, round mass composed of persimmons was removed from the stomach, and an indurated gastric ulcer near the pylorus was seen. The patient died on the fourth postoperative day from bronchopneumonia. The specimen removed weighed 365 grams and measured 6.5 × 18.5 cm.

Fig. 1. Case 3: Two large central defects (arrows) and ulcer niche in mid-portion of lesser curvature.

CASE 3 (No. 90,818): W. A. W., a white farmer, aged 45, was admitted to the University Hospital on March 8, 1937, complaining of epigastric pain, nausea, vomiting, and flatulence. These symptoms had been present since November 1936, at which time the patient had eaten some persimmons. Early in December 1936 he had noticed a hard mass in the epigastrium. For eight years before the onset of this acute pain, he had suffered from "stomach trouble," which he thought was due to hyperacidity, because it was relieved by taking soda.

Roentgen examination revealed two round, movable central defects, evidently foreign bodies, in the stomach, and an ulcer niche on the mid-part of the lesser curvature. The red cell count was 3,950,000; hemoglobin 95 per cent; white cells 14,450, with polymorphonuclears 84 per cent. Gastric analysis showed free hydrochloric acid 0; total acidity 37; lactic acid 0. On gastric aspiration a light brownish fluid was obtained, containing clotted blood.

At operation two dark, plastic, irregular masses were found and removed. The patient made an uneventful recovery.

CASE 4 (No. 94,425): J. C., a 39-year-old white farmer, ate from 20 to 30 persimmons as his noon meal while on a hunting trip about a year prior to admission. Four hours later he had a rather severe epigastric pain, which was relieved by soda. Since that time epigastric pain had occurred almost every day, about two or three hours after meals, and was relieved by alkaline powder or by eating.

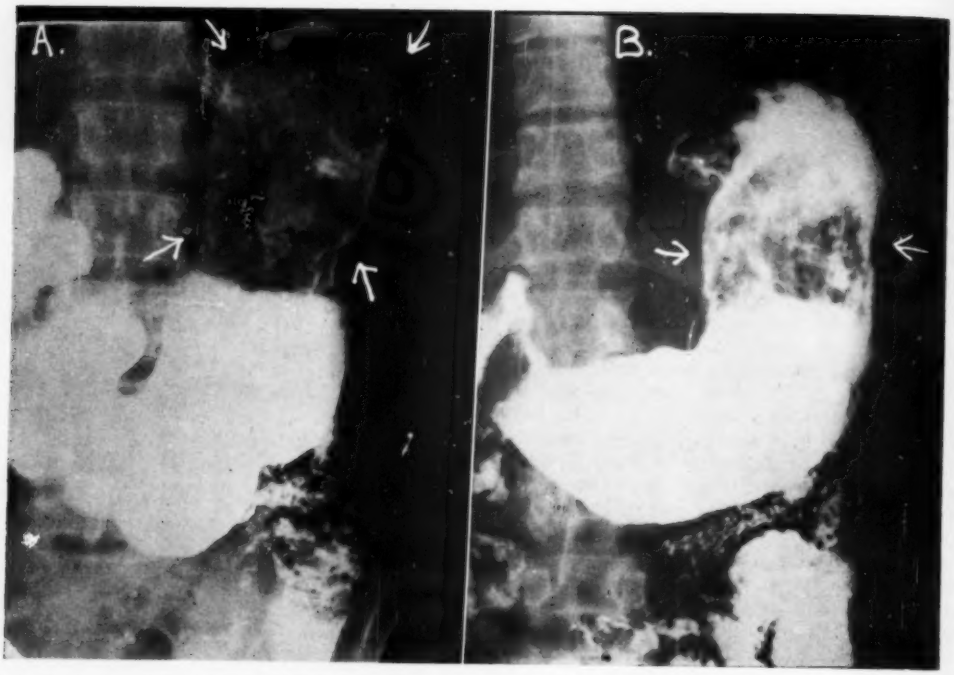

Fig. 2. Case 4: Large bezoar in upper part of stomach. A. Roentgenogram taken in upright position. B. Roentgenogram taken in prone position. Arrows indicate position of bezoar.

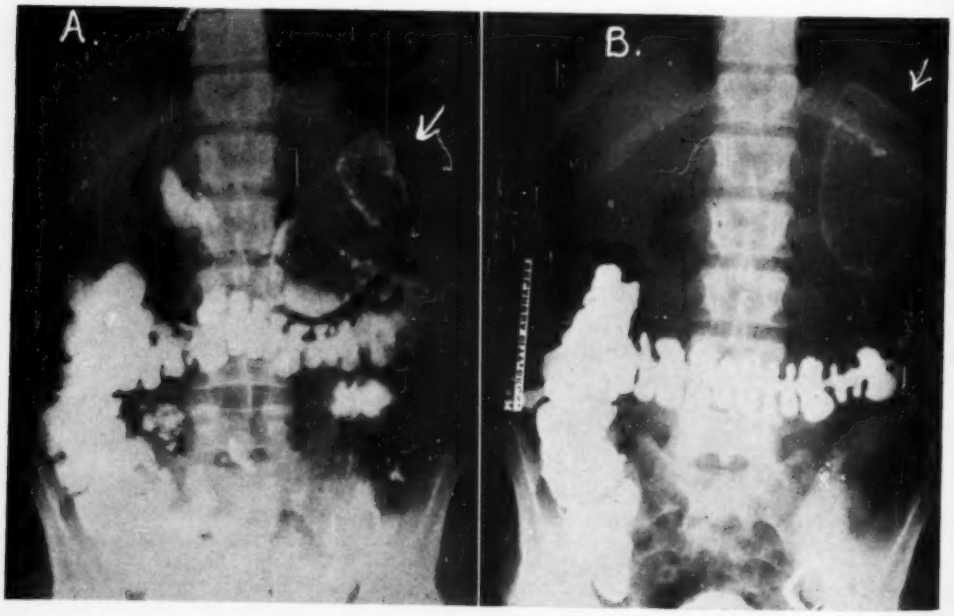

Fig. 3. Case 4: A. Five-hour plate. B. Twenty-four-hour plate. Note barium-coated bezoar in upper left quadrant.

Examination on Nov. 17, 1937, revealed a hard, movable mass in the upper left quadrant which changed location when the patient altered his position. Roentgen examination showed a large central defect within the stomach and on the five and twenty-four hour plates the bezoar was coated with a thin layer of barium. The laboratory findings were: red blood cells 4,800,000; hemoglobin 85 per cent; white blood cells 10,150; polymorphonuclears 76 per cent; free hydrochloric acid 0; total acidity 46.

At operation a large impacted persimmon bezoar was found and removed. Recovery was uneventful.

CASE 5 (No. 56,451): C. D. S., a farmer, aged 40, reported to us because of dull epigastric pain which started three or four hours after meals and was relieved by food. He was frequently awakened at night by pain and occasionally obtained relief by assuming a supine position. Nausea was frequent but there had been no vomiting. Belching was severe and there were occasional sour eructations. No weight loss was noted.

Examination revealed moderate tenderness in the epigastrium. Roentgen examination disclosed a large, freely movable central defect in the stomach. On questioning, the patient admitted eating persimmons twice, approximately eight or nine months previous to admission. He refused surgical treatment, gastric analysis, or any other laboratory examination.

CASE 6 (No. 104,237): V. J., a white housewife, aged 54, ate a large number of persimmons early in November 1939. Next day she complained of weakness, intense epigastric pain radiating up to her "lung," and noticed that her stools were tarry black. A few weeks later she experienced nausea several times but no vomiting. She was admitted to the hospital Dec. 9, 1939. Previous gastric distress was denied. The family and past history were not significant.

Examination revealed a hard, freely movable mass 6 × 10 cm., just left of the epigastrium. Roentgen studies of the stomach showed a freely movable central defect and a large ulcer niche at the mid-part of the lesser curvature. At five hours a mass coated with a thin layer of barium was visualized in the left upper quadrant.

Laboratory findings were: red blood cells 1,590,000; hemoglobin 41 per cent; white blood cells 14,300, polymorphonuclears 88 per cent. The stools were strongly positive for occult blood.

The patient received four blood transfusions without any effect on the blood count and was operated on Jan. 1, 1940. A phytobezoar measuring 6 × 8 cm. was removed and an ulcer niche was seen. On the sixth postoperative day bronchopneumonia developed, complicated by pleural effusion. Death ensued on the fortieth day after operation. At autopsy both the abdominal and gastric wounds were healed. Some adhesions were seen on the lesser curvature corresponding to the gastric ulcer, evidently caused by an old, spontaneously healed perforation.

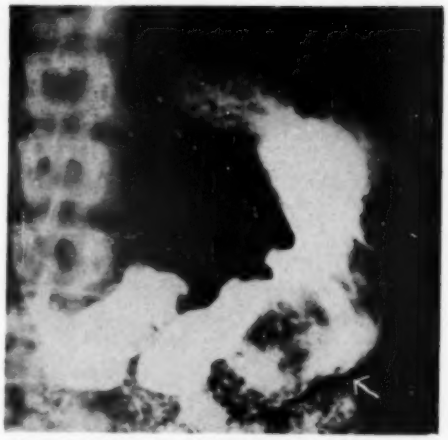

Fig. 4. Case 6: Filling defect in lower third of stomach (arrow) and ulcer niche in mid-portion of lesser curvature.

CASE 7 (No. 100,502): E. Z., a 60-year-old white housewife, gave a history of good health until about five months previous to admission, when she began having a sense of fullness in the epigastrium, slight nausea after eating, flatulence, and eructations. In December 1938 she was awakened at 3:00 A.M. by a cramping, epigastric pain, nausea, and vomiting. Since that time the symptoms had been continuous, being more severe after meals. Soda and a small amount of food gave relief. Constipation had always been a problem but was accentuated after onset of epigastric symptoms. The patient had lost 23 pounds in three months.

Examination revealed a mass in the left hypochondrium which moved with respiration. Roentgen examination disclosed a central filling defect, freely movable on manipulation, and an ulcer niche on the lower third of the lesser curvature. On questioning the patient admitted that she had eaten persimmons prior to the onset of symptoms.

The laboratory findings were: red blood cells 4,200,000; hemoglobin 80 per cent; white blood cells 5,500; polymorphonuclears 54 per cent.

On operation a persimmon bezoar measuring 2.5 × 2.5 inches was removed.

CASE 8 (No. 107,171): C. H., a 51-year-old emaciated white farmer, was admitted on Aug. 16, 1940, with a history of epigastric distress which had been present constantly for three years. The stools were dark. There had been no vomiting. Food aggravated the pain. Six weeks prior to admission the patient had a sudden attack of severe pain and went to another hospital, where he was operated upon for perforated gastric ulcer. A mass was found in the stomach, but operation was restricted to repair of a ruptured ulcer. The pain was somewhat relieved following the operation.

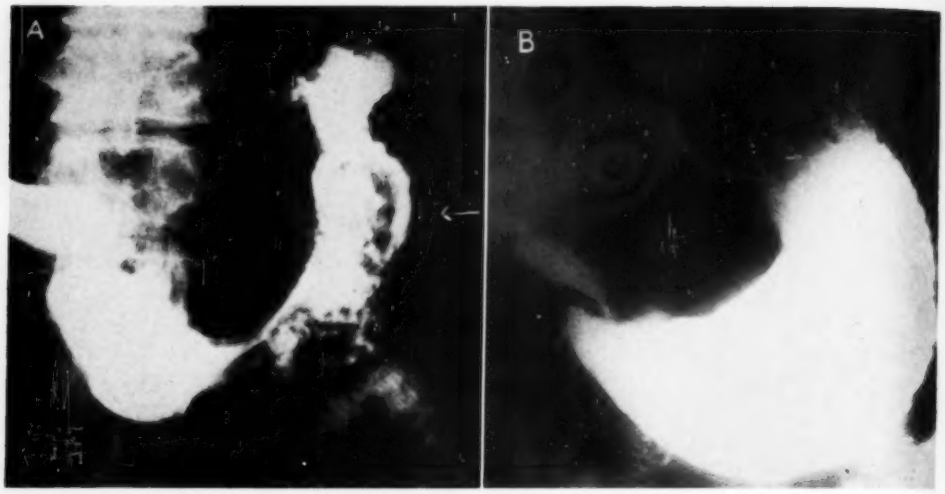

Fig. 5. Case 9: A. Roentgenogram taken with half dose of barium. Note central filling defect at arrow; also ulcer niche at prepyloric part of lesser curvature. B. Roentgenogram taken with full dose of barium. The filling defect is completely obliterated by the excess of barium. Note ulcer niche on prepyloric part of lesser curvature.

Examination revealed a mass in the region of the stomach. Roentgen examination showed a freely movable central defect in the stomach, but no evidence of ulcer was seen. The patient admitted that he had eaten persimmons prior to the onset of symptoms. The laboratory findings were: red blood cells 4,700,000; hemoglobin 94 per cent; white blood cells 600; polymorphonuclears 56 per cent.

At operation a persimmon bezoar the size of a walnut was found and removed. Recovery was uneventful.

CASE 9 (No. 107,898): J. M. M., a 66-year-old, well developed and well nourished white farmer entered the hospital on Aug. 3, 1940, with a history of epigastric pain coming on two or three hours after meals and at night for the past two years. His stools were normal in color, and he had no constipation. He ate persimmons every year.

Roentgen examination revealed a freely movable central defect in the stomach and a large ulcer on the prepyloric part of the lesser curvature. The laboratory findings were: red blood cells 4,520,000; hemoglobin 86 per cent; white blood cells 6,500; polymorphonuclears 67 per cent; free hydrochloric acid 75; total acid 97.

At operation a persimmon bezoar, 1.5 inches in diameter, was removed. Recovery was uneventful.

SUMMARY

Nine cases of phytobezoar of persimmon origin and an investigation of bezoar formation *in vitro* have been presented.

It was found experimentally that hydrochloric acid is essential for the formation of persimmon bezoars. Neither prunes, raisins, celery, nor completely ripe persimmons formed bezoars *in vitro*.

Incompletely ripe persimmons formed bezoars in any solution of hydrochloric acid with or without pepsin, but not in water or alkaline solutions.

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Skull Laminagraphy

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THE ADDITION of laminagraphy to the usual roentgen examinations of the skull provides information which may supplement that otherwise obtained. Briefly, laminagraphy is the procedure by which predetermined layers of a structure may be visualized roentgenographically. It involves making the x-ray exposure while the tube and film move synchronously in opposite or spiral directions. It is known also as "tomography," "stratigraphy," "planigraphy"—all implying visualization of a single plane within a structure. The technical aspects have been thoroughly discussed in other publications (1), and application of the technic to chest roentgenography is well known (2).

The possibilities of laminagraphy in studies of the cranium have been mentioned by Bozzetti, by Ziedses des Plantes, by McDougall and Twining, and di Rienzo and Boher, all of whom studied the normal skull (3). Froment and Buffé describe a case of tumor of the base of the skull in which laminagraphic studies were contributory to the correct diagnosis (4).

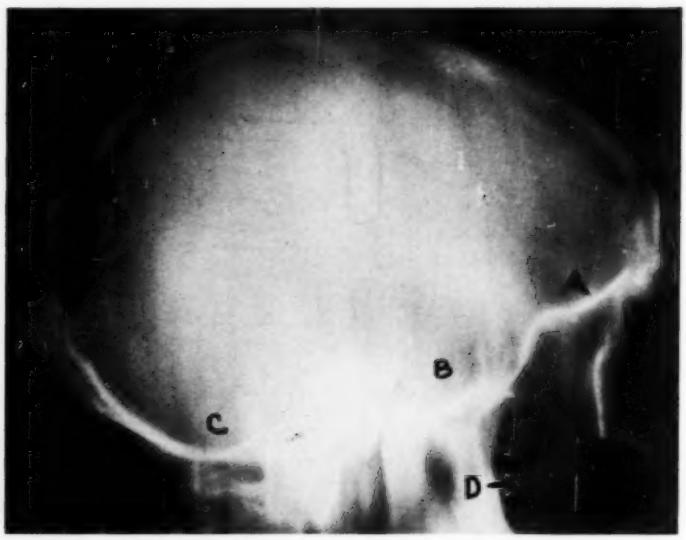

Fig. 1 A. Lateral laminagram at the 2.5-cm. level. The anterior, middle, and posterior fossae are designated, respectively, as A, B, and C. The arrow marked D indicates the maxillary sinus.

Cone, Moore, and Dean have applied the procedure to the radiologic study of the paranasal sinuses (5).

METHOD

In the present study serial laminagraphic studies of the skull were made of normal persons and patients with intracranial pathology. An attempt was made to fix the regions which might advantageously be studied routinely, bearing in mind the necessity of knowing the anatomy of the skull as seen in serial sections. The results

[1] From the Radiologic Service of M. G. Wasch, M.D., The Jewish Hospital of Brooklyn. Accepted for publication in October 1939.

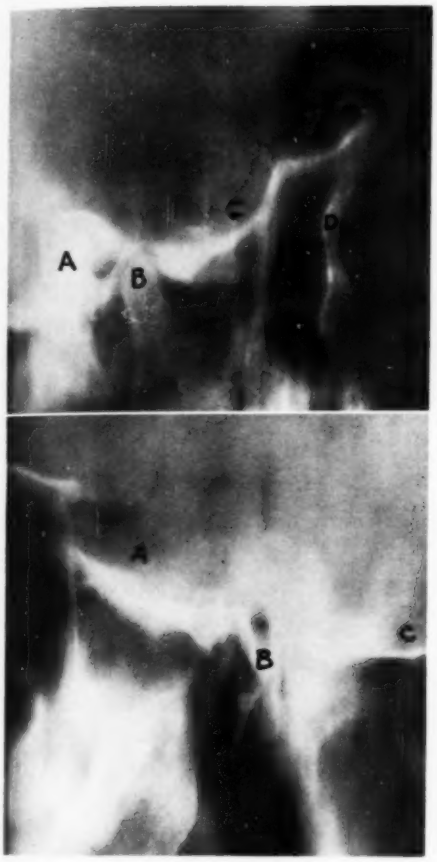

Fig. 1 B (above). Lateral laminagram at 2.5-cm. depth. A. Temporal bone. B. Temporomandibular joint. C. Middle cranial fossa. D. Cut section of the zygomatic process of the maxillary bone. E. Anterior fossa.

Fig. 1 C (below). Laminagram at 2.5-cm. depth. A. Middle fossa. B. Styloid process. C. Posterior fossa.

were compared with those obtained from lateral stereoroentgenograms and posteroanterior and anteroposterior views of the skull.

The apparatus used for making the laminagrams in this study was that devised by Alexander (6). This operates by means of a pulley system which moves the film carriage and tube stand simultaneously. Various ratios of motion may be obtained by varying the number of pulleys used to draw the film carriage. Since the motion is purely rectilinear, streaky artefacts may

Fig. 2 A. Normal skull, lateral projection.

appear on the films. These do not interfere with the diagnostic value of the latter, and can be kept at a minimum with a well oiled, smoothly running apparatus. As an additional precaution for avoiding artefacts the radiographic exposure should not start before the run is in progress, nor continue after it ends. Alexander's device has the advantage of being readily adapted to standard equipment at slight expense.

The bony detail on laminagrams is inferior to that obtained on the ordinary roentgenogram. Only a thin layer of tissue is in critical focus, the remainder of the structure being eliminated by "blurring." The structures closest to the plane in critical focus are not so completely blurred as more distant areas, and impair bone detail by casting a haze over the plane in critical focus. With more elaborate apparatus the thickness of the plane in critical focus can be varied by the operator.

THE NORMAL SKULL

Laminagrams of the skull in the lateral projection were made at depths of 2.5 cm., 5 cm., and 7.5 cm. In most cases the 7.5-cm. plane corresponded to the center of the skull. The patients were all adults.

The following structures are visible at a depth of 2.5 cm.:

1. The frontal fossa, formed by the

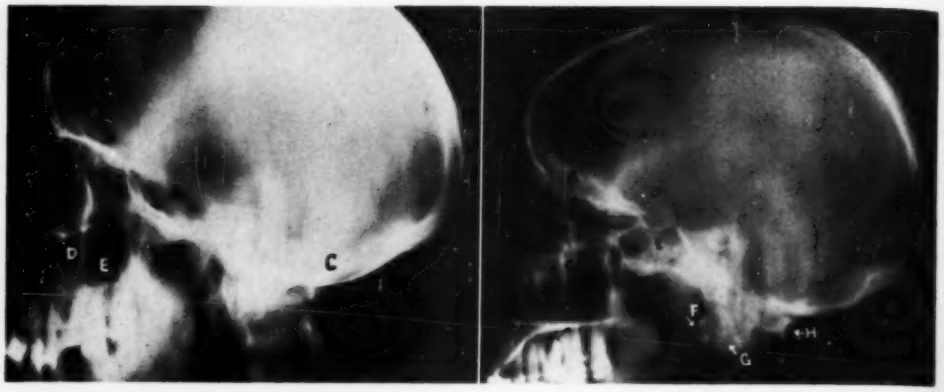

Fig. 2 B (left). Laminagram of the skull shown in Fig. 2 A, at 5-cm. depth. A. Anterior fossa. The thickness of the frontal plate is well demonstrated. B, the middle fossa, is narrower than at 2.5 cm. C. Posterior fossa. D. Section through the base of the zygomatic process of the maxillary bone.

Fig. 2 C (right). Laminagram at 7.5-cm. depth. A. Cribriform plate. B. Ethmoidal air cells. C. Nasal cavity, in which the conchae are seen. Immediately beneath D is the sella turcica. E. Air space of the sphenoidal sinus. F. Anterior portion of the first cervical vertebra. G. Odontoid process. H. Posterior portion of the first cervical vertebra. I. Posterior fossa. J. Internal occipital protuberance.

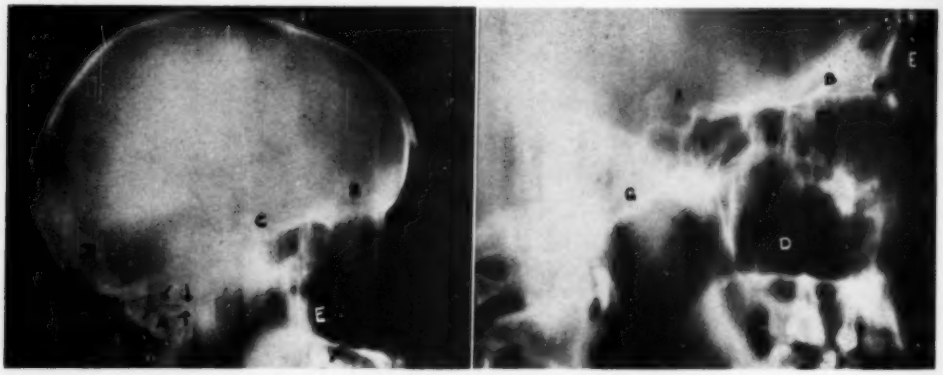

Fig. 3 A (left). Lateral laminagram at 7.5-cm. depth. A. Atlanto-occipital articulation. B is directly above the cribriform plate, and C above the sella turcica, beneath which the sphenoidal cells are visible. D. Posterior fossa. F. Hard palate.

Fig. 3 B (right). Lateral laminagram at 7.5-cm. depth. Immediately beneath A is the sella turcica. B. Cribriform plate. C. Ethmoidal cells. D. Maxillary sinus. E. Frontal sinus. F. Sphenoidal sinus. G. Basilar portion of the occipital bone.

orbital plate of the frontal bone. This is usually concave, and is higher in its anterior portion than at its junction with the lesser wing of the sphenoid bone. The bony structures in the same plane, such as the cut section of the zygoma, and occasionally a portion of the antrum are visualized.

2. The middle fossa, which is formed by the great wing of the sphenoid and the temporal bone. The temporo-mandibular articulation and the styloid process may also be seen, as well as the external auditory canal. The condyle of the mandible is occasionally visualized.

3. The occipital fossa, formed by the occipital bone. The occipital bone at this level is usually thinner than at deeper levels.

At 5-cm. depth the following structures may be seen:

1. The frontal plate, forming the roof of the orbit, is somewhat thicker and higher

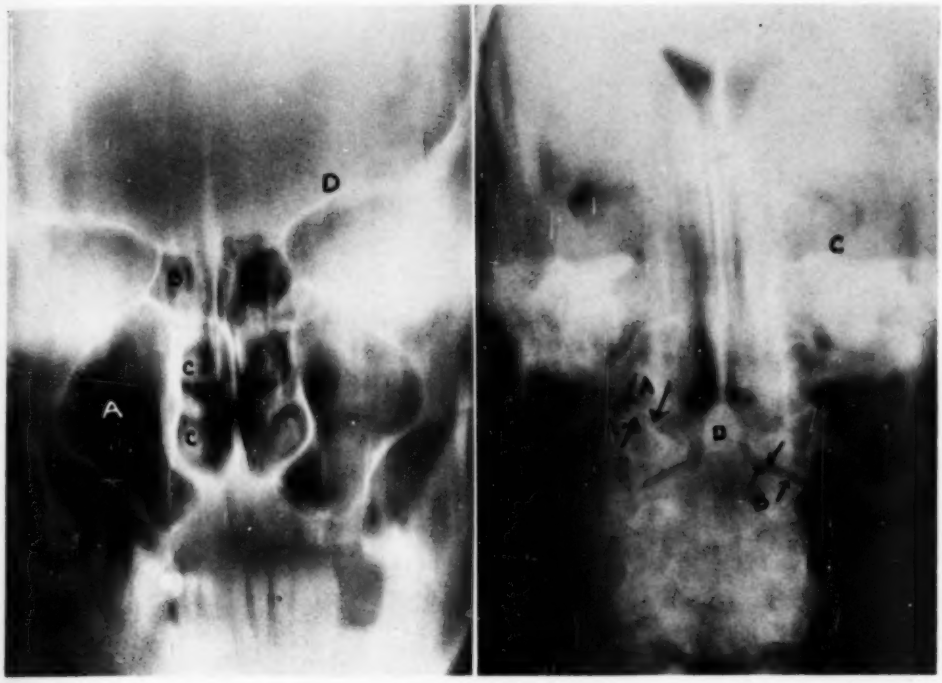

Fig. 4 A (left). Laminagram 4 cm. from the forehead. A. Maxillary sinuses. B. Ethmoidal sinuses. C. Nasal turbinates. D. Orbital plates of the frontal bones.
Fig. 4 B (right). Laminagram 10 cm. from the forehead. A. Atlanto-occipital articulation. B. Articulation between the first and second cervical vertebrae. C. Petrous portion of the temporal bone. D. Odontoid process. The patient's mouth was closed while this film was taken.

than at 2.5 cm. It assumes a straight or convex appearance, slanting down from its anterior portion to its termination in the lesser wing of the sphenoid bone or the anterior clinoid process of the sella turcica.

2. Immediately beneath the frontal plate, septa of the ethmoidal air cells may be seen. The orbit is cut through, and the maxillary sinus and alveolar ridge of the maxillary bone are visualized. The frontal sinus likewise is cut longitudinally.

3. The middle fossa is narrower than at the 2.5-cm. level. The petrous portion of the temporal bone can be seen in cross-section and on some films the internal auditory meatus as well as some of the mastoid air cells may be seen.

4. The posterior fossa.

At a depth of 7.5 cm. the following structures may be seen:

1. The cribriform plate replaces the frontal plate in the structure of the frontal fossa. This is seen as a shadow of lesser density than the frontal plate, and on some films interruptions in the continuity of the bone indicate the presence of perforations.

Fig. 4 C. Laminagram 10 cm. from the occiput, in patient ten years old. A. Temporal bone.

2. Beneath the cribriform plate some

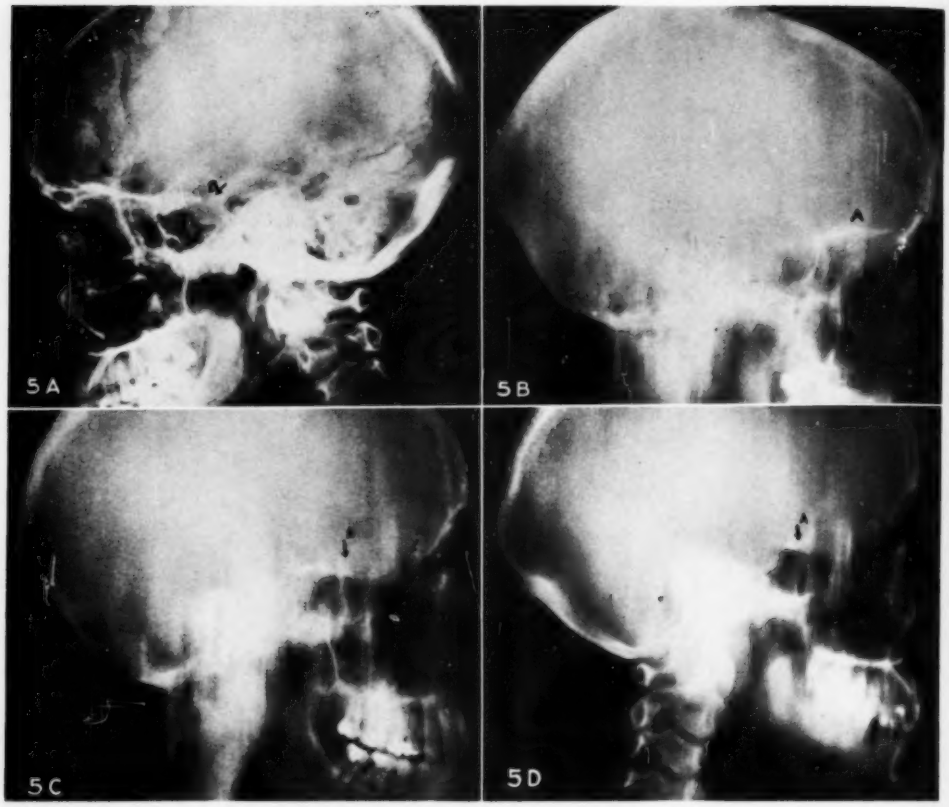

Fig. 5. Case 1: Frontal lobe meningioma.
5 A. Lateral projection of the skull. A. Superimposed orbital plates. B. Sella turcica. Note the loss of bony density of the anterior portion of the sella and the erosion of the posterior clinoid processes.
5 B. Laminagram 5 cm. from right lateral wall. A. Intact frontal plate.
5 C. Laminagram 5 cm. from left lateral wall. A–A. Loss of bony density of left orbital plate.
5 D. Laminagram 7.5 cm. from left lateral wall. A–A. Soft tissue shadow pressing upon the left ethmoidal cells.

of the ethmoidal air spaces are visualized. The nasal conchae can be seen, and the hard palate is cut in cross-section.

3. The tuberculum sellae, the sella turcica, and the posterior wall of the sella are visible. Immediately beneath the sella the air space of the sphenoidal sinus is well demonstrated. The basilar portion of the occipital bone and the foramen magnum are visualized. The odontoid process and the anterior and posterior aspects of the first cervical vertebra can be seen.

4. The posterior fossa is cut in its mid portion, and the internal occipital protuberance can sometimes be seen.

Serial sections of the skull also afford an excellent index of the thickness of the cranial wall in the particular plane examined. This may give useful information concerning local atrophy or hyperostosis, as will be illustrated in the cases to be presented below.

Studies in the postero-anterior and the anteroposterior projections can, at proper levels, bring out the maxillary and ethmoidal sinuses. The sphenoidal sinus can be examined in the coronal planes, and the depths of the orbits may be explored. The nasal conchae also are better visualized than on routine roentgenograms. The odontoid process, the atlanto-occipital articulation, and the articulation between

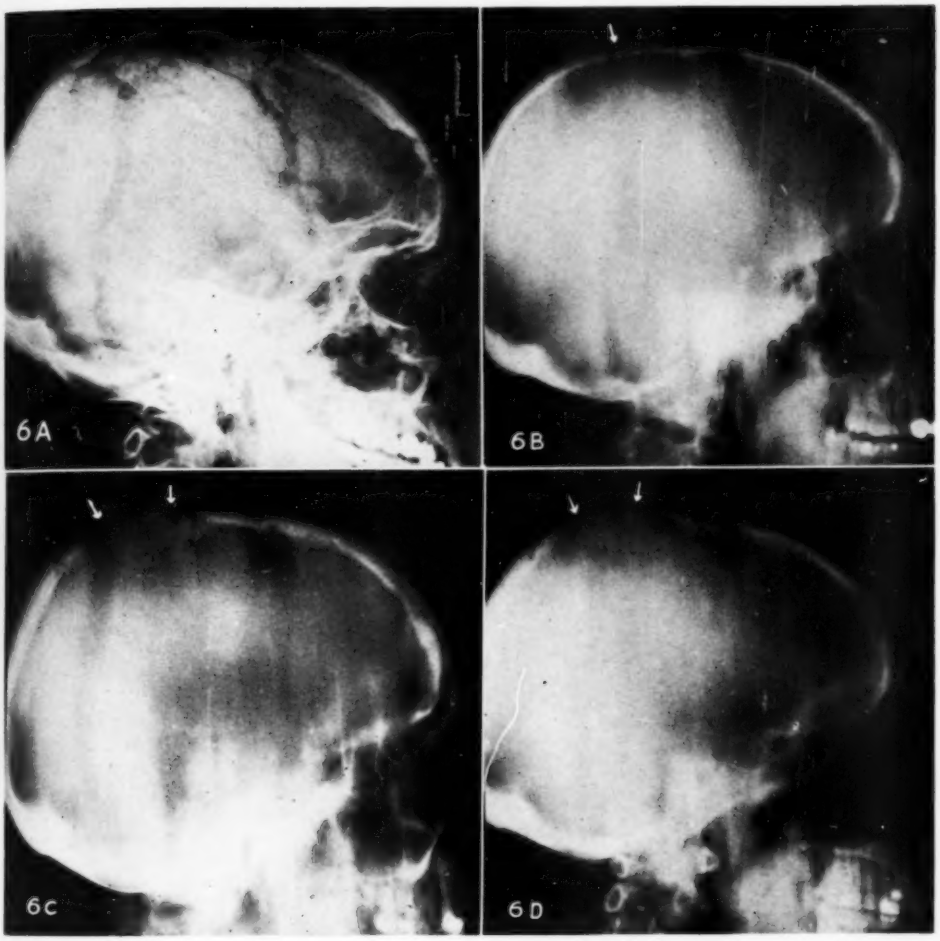

Fig. 6. Case 2: Meningioma invading parietal bone.
6 A. Lateral skull. Note the marked increase in the vascular markings.
6 B. Right lateral laminagram at 7.5-cm. depth. The arrow points to the intact parietal bone.
6 C. Laminagram 5 cm. from left lateral wall. The arrows point to the thinning of the left parietal bone.
6 D. Laminagram 7.5 cm. from the left lateral wall. The arrows point to the thinning of the bone at the skull vertex.

the first and second cervical vertebrae can be demonstrated with the patient's mouth closed and with a minimum of manipulation.

REPORT OF CASES

CASE 1: G. C., a 25-year-old woman, complained of headaches for nine years. These had become increasingly severe, and for six months before admission were uncontrollable. Brief lapses in consciousness associated with the menstrual periods had occurred for nine years. Vision had been blurred for two months, with a constant scotoma in the left visual field. Physical examination was not contributory.

Routine roentgenograms and pneumencephalograms showed a somewhat enlarged sella with atrophic posterior clinoid processes and dorsum sellae. The pineal shadow was displaced toward the right.

Laminagraphic sections 5 cm. from the right lateral wall showed a normal frontal plate. A similar cut in the left lateral projection showed absence of the frontal plate and a soft tissue shadow pressing downward toward the ethmoidal air cells. The anterior clinoid processes were intact.

Another laminagraphic section 7.5 cm. from the left lateral wall passed through the center of the

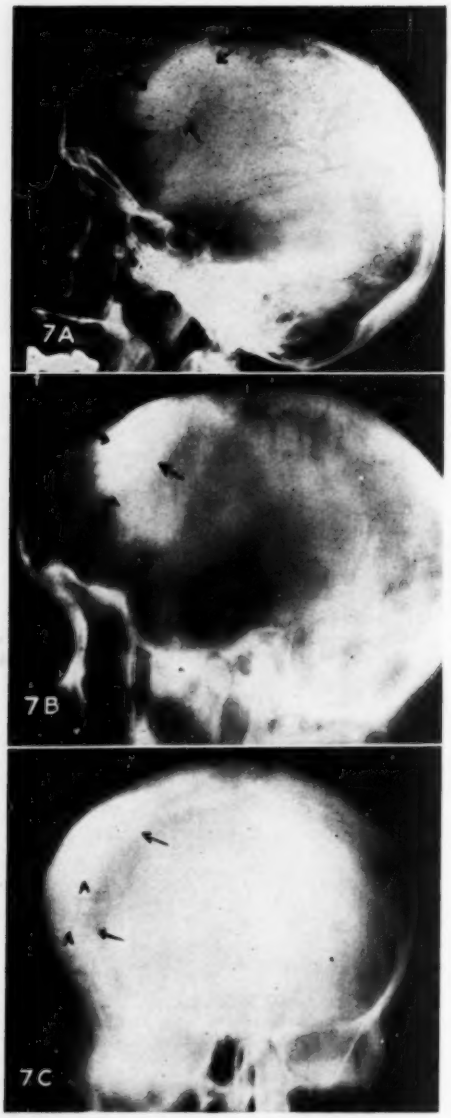

Fig. 7. Case 3: Meningioma of right frontal lobe, with hyperostosis of overlying bone.
7 A. Lateral roentgenogram of the skull. The arrows outline the hyperostotic area.
7 B. Laminagram 2.5 cm. from right lateral wall. The arrows indicate the hyperostotic area.
7 C. Laminagram 7.5 cm. from the forehead. The thickness of the right side of the skull is well demonstrated. A–A. Vascular channel entering the thickened bone.

skull. A depression in the cribriform plate similar to that seen on the preceding sectional view was present.

These findings were interpreted as indicating the presence of a neoplasm in the left frontal lobe pressing on the frontal plate. At operation a left frontal lobe meningioma was found. The frontal plate was considerably thinned.

CASE 2: L. W., a 47-year-old housewife, complained of numbness of the entire right side of her body for seven years. She had left temporal headaches for three years, with nausea and diminishing vision. On physical examination bilateral choked discs were found.

Routine roentgenograms of the skull showed a considerable increase in the vascular channels of the left side of the skull, the channels leading into large lakes in the parietal region.

Laminagraphic sections were made 6 cm. and 7.5 cm. from the left lateral wall. Both sections showed thinning of the parietal bone with vascular impressions in the thinned areas. A control section made 7.5 cm. from the right lateral wall revealed uniform thickness of the right parietal bone.

The findings were interpreted as indicating invasion of the left parietal bone by an underlying neoplasm. At operation a meningioma invading the parietal bone was found. Microscopic study of the bone confirmed this observation.

CASE 3: D. G., a 37-year-old housewife, was admitted with a history of episodes of unconsciousness for fifteen years. No convulsive attacks had occurred. There had been progressive enlargement of the right side of the head. On physical examination a stony hard mass 5 to 6 cm. in diameter was found in the right fronto-parietal region contiguous with the underlying skull. The reflexes were sluggish.

Routine roentgenograms of the skull showed an oval area of bony condensation in the right fronto-parietal region. A right lateral laminagram at the 2.5-cm. level clearly demonstrated the area of condensed bone. Another laminagram made in the coronal projection at 10 cm. from the brow completed the picture of the pathologic process. The bone condensation increased the thickness of the right vault of the skull appreciably and involved the temporal bone. A blood vessel could be seen entering the lower portion.

The findings indicated an osteosclerotic process involving the right frontal, parietal, and temporal bones. At operation a meningioma of the right frontal lobe was found with considerable hyperostosis of the overlying bone.

CASE 4: H. S., a 28-year-old man, was admitted because of the discovery of a large osteoma occupying the frontal sinuses. Neither his history nor physical examination indicated the presence of organic central nervous system disease.

The routine roentgenograms showed a large osteoma filling the lower portions of the frontal sinuses, which were large.

Lateral laminagraphic studies were made at the 5- and 7.5-cm. levels. The structure of the osteoma was clearly demonstrated. Its thickness varied considerably in the various planes examined; portions

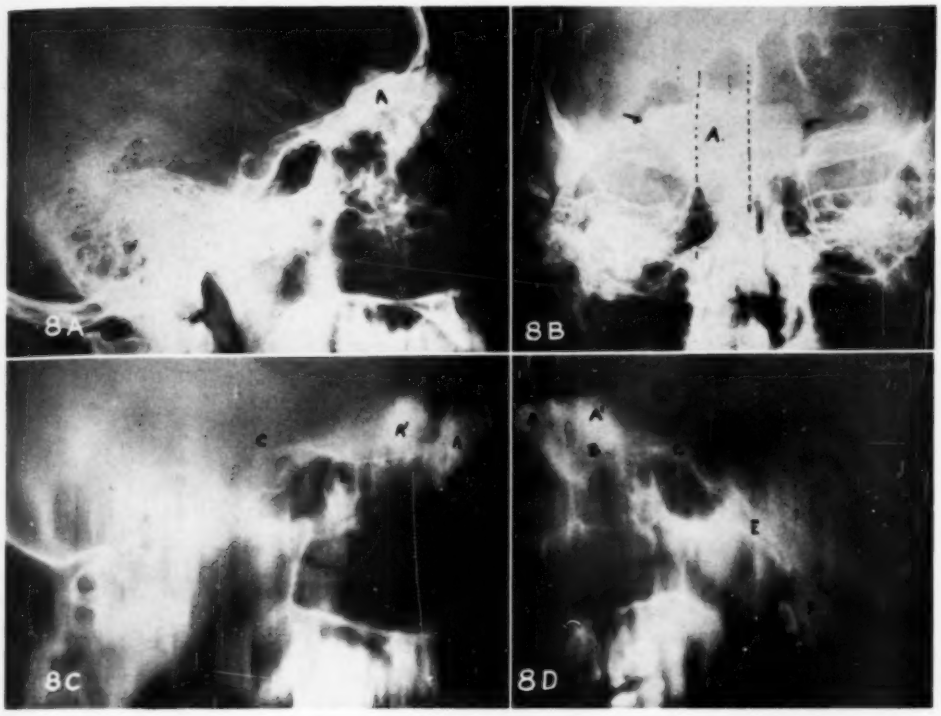

Fig. 8. Case 4: Osteoma of frontal sinuses.

8 A. Lateral roentgenogram. A. Frontal osteoma.

8 B. Postero-anterior roentgenogram. A. Osteoma. The dotted lines indicate the cuts taken from the lateral laminagrams.

8 C. Right lateral laminagram at 6.5-cm. depth. A. Portion of osteoma within the frontal sinus. A'. Portion of osteoma within the frontal fossa. B. Posterior ethmoidal cells. C. Intact anterior clinoid process.

8 D. Right lateral laminagram at 7.5 cm. A. Osteoma within the frontal sinus. A'. Osteoma within the frontal fossa. B. Invasion of anterior ethmoidal cells. C. Tuberculum sellae. D. Posterior wall of sella. E. Basilar process of the occipital bone. F. Odontoid process.

were entirely within the frontal sinuses as well as within the cranial cavity and underlying ethmoid cells.

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Patellar Anomalies, Roentgenologic and Clinical Consideration[1]

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THE KNEE JOINT being a complex mechanism, the functions of walking and weight-bearing are not infrequently attended by disability. It is in an effort to discover the cause of dysfunction of the knee joint that patellar anomalies are encountered. In this paper we wish to summarize briefly the history of such anomalies and to classify and report seven cases; then to discuss the pathogenesis and differential diagnosis and finally add a word about treatment and medico-legal significance.

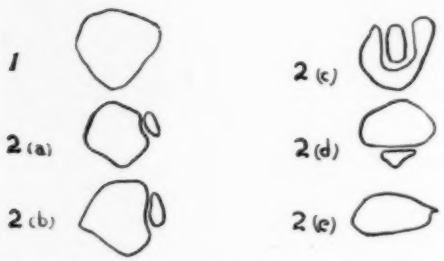


Fig. 1. Diagrammatic representation of patellar anomalies.

HISTORY

The history of patellar anomalies may be divided in two periods, before and after the advent of roentgenology and industrial compensation. Before the advent of roentgenology, patellar anomalies were found largely in the dissecting room, except in isolated cases where the condition was obvious in the living. These cases were then only of scientific interest, but the passage of compensation laws has endued them with medico-legal significance. The ease with which an anomaly may be confused with fracture has made accurate diagnosis more imperative if the ends of justice are to be served.

Among those who describe cases before the development of roentgenology are Grüber (4), 1883, and Thorndike (14), 1898. Since that time accretions to our knowledge of this condition have been added by Joachimistal, 1902, Köhler, Larsen, Johansson, Todd, and McCally. Articles by George (4), Giles (5), Smith (15), Speed (16), and others have dealt with this condition.

An excellent classification with diagrams illustrating the various types of anomalies which he has encountered is given by Smith (15). To this classification we would like to make one addition. The modified classification is then as follows:

1. Emarginate patella with a conical or triangular projection at the upper and outer quadrant.
2. Bipartite patella.
   - (*a*) Small fragment at the upper and outer quadrant. This is the most common type.
   - (*b*) Vertical fissure usually seen in the lateral quadrant.
   - (*c*) A doughnut patella, "U" shaped with a small fragment between the arms of the "U."
   - (*d*) Transverse fissure, seen usually at the lower pole.
   - (*e*) Linear-like fragment at the lower pole of the patella, which may be almost in contact with lower margin of the patella.

Diagrams of the types described above are shown in Figure 1.

The various significant types which we have encountered will be seen from the ensuing case reports and accompanying reproductions.

CASE REPORTS

CASE 1 (No. 180,577): The patient, R. S., came into the hospital complaining of pain in the lower back and right knee. The pain in the knee was initiated by a fall and was of two months' duration.

[1] From The Radiologic and Orthopaedic Departments, Henry Ford Hospital, Detroit. Accepted for publication in April 1941.

It was aggravated by motion but did not disappear with rest. The sacro-iliac pain was of more recent origin.

Physical Examination: The patient was a well developed, well nourished, white male, aged 26. Muscle spasm and tenderness were present over the left sacro-iliac articulation. There was some pain in the lower third of the patella, infrapatellar fat pad, and patellar tendon.

X-Ray Findings: There was fragmentation of the outer and upper quadrant of the patella.

Course: The patient was given postural exercises and physical therapy to the back. The knee caused him no further trouble.

CASE 2 (No. 191,890): The patient, C. W., complained of pain in the left knee and low back of one week's duration. One week previous to his first visit he was struck by a truck and received injuries to the left hip and right side of the head. He was unconscious for an hour.

Physical Examination: The patient was an undernourished white male, aged 41. Palpation showed the lower back and the left knee to be tender. There was increased lateral mobility. Some tenderness was elicited over the lateral ligaments. No inflammation or thickening could be made out about the knee joint.

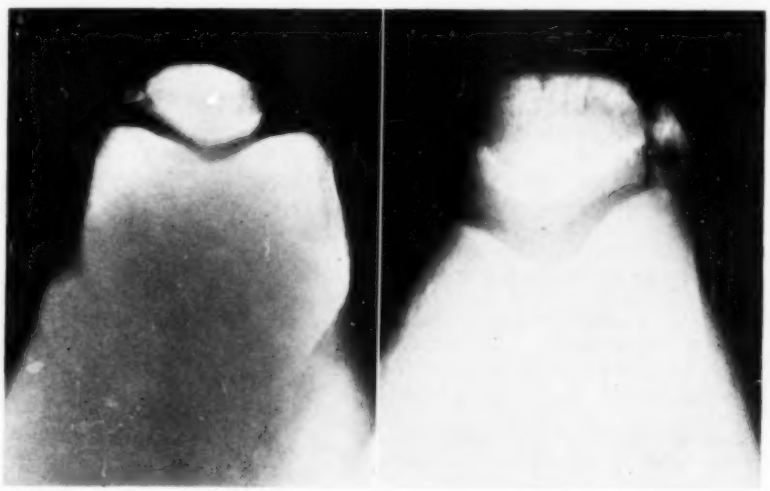
X-Ray Findings: A vertical fissure was seen at the junction of the middle and outer thirds of the patella.

Course: Physical therapy was given, and the patient recovered and returned to work.

CASE 3 (No. 105,702): W. B. was brought into the hospital because of recurrent patellar dislocations on the left side. This had happened on three previous occasions. Pain and swelling existed for two or three days and the swelling then subsided and pain disappeared.

Physical Examination: The patient was a well developed white boy, aged 8 years. There was an increase of fluid in the knee joint, and the knee had a boggy feel as though the joint contained blood. There was some tenderness over the joint line and along the medial edge of the left patella. The patellar ligament was relaxed. The left patella was mobile.

X-Ray Findings: A vertical view of the patella shows a small fragment of bone along the medial side of the patella.



Figs. 2–3. Cases 1 and 2.

Fig. 2 (left). Case 1: Fragmentation in outer and upper quadrant of patella. This corresponds to bipartite patella, 2 (*a*) in the diagram (Fig. 1).

Fig. 3 (right). Case 2: Vertical fissure at junction of middle and outer third of patella, corresponding to 2 (*b*) in Fig. 1.

Course: The patient was seen last four days after the dislocation; swelling and other symptoms were subsiding.

CASE 4 (No. 162,662): The patient, J. R. B., was brought into the hospital because of a swollen, painful left knee. The knee was injured six weeks previously and had been in a cast for four weeks. The swelling recurred when the splint was removed. The child had enlarged nodes and had been treated for anemia.

Physical Examination: The patient was a white boy, 11 years of age, with a scar over the left knee cap. This was an old scar and its cause was not known by the patient. There was bilateral swelling of the infrapatellar fat pad and definite tenderness over the lower pole of the left patella. No swelling or effusion of the knee joint was seen.

X-Ray Findings: A small fragment of bone was seen just below the lower pole of the left patella.

Course: This patient was seen five months after the first observation. He gave a history of pain in both knees after strenuous exercise. This was of several weeks' duration. There were tenderness and swelling over each infrapatellar fat pad. Six months after the first observation the boy was again seen. He had had pain in the region of the right tibial tubercle for six weeks, which was noticeable after strenuous exercise. He had also observed swelling in the region of the tibial tubercles and examination confirmed this. There was slight increase in local heat over these areas and the changes were more pronounced on the right than on the left.

Diagnosis: Johansson-Larsen's disease was the diagnosis first made; on second observation a diagnosis of Osgood-Schlatter's disease was added.

CASE 5 (No. 51,988): J. R. L., an obese white boy, 13 years of age, complained of pain in the left knee joint for one month. There had also been pain in the right knee joint for about the same period. There had been very little change in the character of the pain since onset.

Past History: The patient was seen in this hospital in 1924, suffering from congenital spastic diplegia. An obturator neurectomy and sympathectomy had been done. The gait improved with employment of reconstructive orthopedic measures.

Physical Examination: There was tenderness over the lower pole of each patella. The tibial tubercles were prominent.

X-Ray Findings: A beak-like fragment was seen at the lower pole of the left patella. The right patella was negative.

Course: Orthopedic measures were employed and physiotherapy was given. The patient became symptom-free. A year later pain again developed in the right knee. There was definite tenderness over the right tibial tubercle; also limitation of flexion of the knees. This persisted despite corrective measures. There was pronation of the feet. The gait was still somewhat spastic and shuffling.

CASE 6 (No. 69,305): This patient, C. H., complained of pain and stiffness in the left knee of one year's duration. This was aggravated by changes of weather.

Physical Examination: The patient was a white female, aged 61. The left knee extended to an angle of 155°, 20° short of extension possible in the right knee. No soft tissue thickening was present. There were moderate pain and tenderness along the internal lateral ligament. No instability was demonstrated.

X-Ray Findings: Fragmentation in the outer and upper quadrant of the left patella was present. There was evidence of hypertrophic arthritis.

CASE 7 (No. 255,619): The patient, L. B., complained of pain in the left knee. The onset of this pain dated back two or three weeks previous to her first visit. She walked occasionally with a limp. Pain was noticed particularly when the knee was flexed, but sometimes the knee hurt her when she was in bed. No definite history of injury could be elicited. Neither had there been any swelling of the knee.

Physical Examination: Posture was poor. Examination of the knee showed no pain on motion or manipulation. Except for posture, physical examination was negative.

X-Ray Findings: Bilateral fragmentation in upper and outer quadrant of each patella was found.

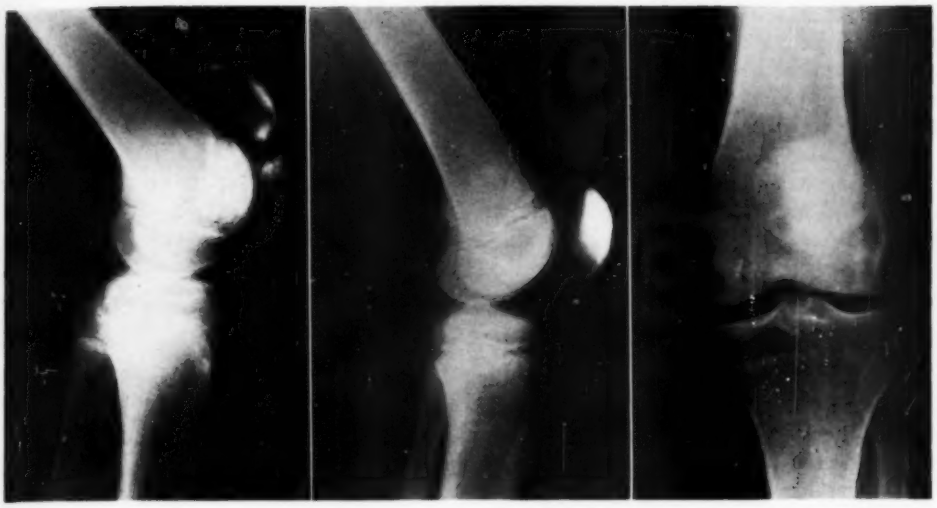
PATHOGENESIS

Whether the multipartite patella is the result of failure of union of separate ossification centers or is a localized osteochondritis is still a moot question. The trend of opinion during the past decade has favored the osteochondritic point of view. The earlier groups of authors and some more recently, notably King (9), have questioned this idea.

Some authors believe that the emarginate patella and the fragmented or multipartite patella of adults are the result of an osteochondritis, occurring during the ossification or developmental period. It is considered to be a process similar to that seen in Osgood-Schlatter's disease of the tibial tubercle, Legg-Calvé's disease of the upper femoral epiphysis, Sever's apophysitis of the os calcis, and other described epiphysitides.

Osteochondritis is seen clinically chiefly in healthy, overweight, active children in early puberty. A history of trauma is either denied or minimal. More severe cases may result in local joint effusion, or simply local pain, after mild injury.

It is our feeling that an osteochondritis in the patella should show evidence of end-results similar to those observed in osteochondritis elsewhere, namely, ultimate healing and union with the main fragment —albeit with deformity—but certainly not a continued separate existence even into adult life. One should find in the patella the counterpart of the final stages of epiphysitis seen elsewhere, as in the hip (malum coxae senilis), the os calcis, the tibal tuberosity, or the kyphosis of Scheuermann. George (4) recently described



Figs. 4–6. Cases 5, 4, and 6.
Fig. 4 (left). Case 5: Transverse fissure at lower pole of patella, corresponding to 2 (*d*) in Fig. 1.
Fig. 5 (center). Case 4: Linear-like fragment at lower pole of patella, corresponding to 2 (*e*) in Fig. 1.
Fig. 6 (right). Case 6: Fragmentation of upper outer quadrant; bipartite patella, corresponding to 2 (*a*) in Fig. 1.

articular cartilage between fragments of a bipartite patella on histologic examination. This, one would not expect to find in an old osteochondritis.

According to Piersol (12), the patella first appears as a cartilaginous point in the course of the third fetal month. Several ossification centers appear between two and five years of age. These unite to form a central mass from which ossification progresses. Ossification is complete shortly after puberty. Gray (6) places the appearance of the ossification center more definitely at the second or third year. Adams and Leonard (1) place the appearance time of ossification in the fifth and sixth years and state that it proceeds from one center.

Shands (14), in 1926, analyzed roentgenograms of 100 patellae in children from two and a half to six years of age. In this group the earliest evidence of ossification appeared at two and a half years, the latest at six years.

The pathology, according to Overton (11), is that of an aseptic necrosis brought on by insufficient epiphyseal nutrition during periods of rapid growth. This is aggravated by use, and trauma of some degree may well influence the appearance of symptoms. Such a joint is susceptible to strain. Symptoms appear after prolonged use, as in marching, or they may never appear if some slight trauma does not initiate them.

George (4) and others feel that merely a failure of union of these two ossification centers explains satisfactorily the whole problem. The question yet to be answered is: "Which theory for the explanation of the multipartite patella is correct, or do both contribute to the entity as we know it?"

DIFFERENTIAL DIAGNOSIS

The differential diagnosis between patellar anomaly and fracture is important and is sometimes difficult. Usually it can be made accurately if the history, physical, and roentgen findings are correlated. In cases of anomaly the trauma is usually indefinite and inadequate to explain the findings observed on the films. The clinical findings do not harmonize with the

roentgen observations. In cases of fracture, the injury is adequate to produce the findings observed on the films, which are those associated with this condition. In anomaly the fragment is smooth and entirely bounded by cortical bone, but in fracture the outline of the fragment is serrated and only partially bounded by cortical bone. In anomaly the adjacent surfaces of the fragments are uniformly separated throughout their entire length but in fracture the space intervening between the fragments is of varying width. A fracture line is rarely seen in the upper and outer quadrant and is usually unilateral, whereas in anomaly the fissure is almost always in the outer and upper quadrant and frequently is bilateral. Bilateral roentgenograms of the knees are often very helpful and may make it possible to establish the diagnosis beyond any reasonable doubt.

TREATMENT

Rest and immobilization are generally sufficient to control the acute symptoms. Surgery is rarely indicated for removal of a fragment. The condition should be recognized in early adolescence and protective measures instituted to avoid undue strain on the extension apparatus of the knee.

MEDICO-LEGAL SIGNIFICANCE

The medico-legal entanglements which may arise from confusing patellar anomaly with a fracture of this bone are well illustrated by two cases reported by George and Leonard (3) in 1925. These patients had been drawing compensation for weeks. In one, compensation was allowed because anomaly had been mistaken for ununited fracture and some degree of permanent disability was expected. Recently the authors testified in a somewhat similar case before a labor board. We showed that the opposite knee, although asymptomatic, was identical in appearance with the knee in question. The other factors mentioned in the differential diagnosis were brought out and full compensation was denied.

SUMMARY

A brief history of the development of our knowledge of patellar anomalies is reviewed. A classification of the types met with in the literature is presented. Pathogenesis and treatment are briefly considered. Attention is called to the medico-legal significance of this condition. Seven case reports are submitted.

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Abdominal Pregnancy[1]

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WITH THE ADVENT of pneumoperitoneum, hysterography, amniography, and uterine soft-tissue studies, certain information of considerable value has been made available to the obstetrician.

Pregnancy with its many complications can often be diagnosed early by means of roentgen examination, and the use of this method in the determination of abdominal pregnancy has become an important phase of obstetrics. This fact is of particular interest since abdominal pregnancy is considered to be an uncommon condition, and its diagnosis is often difficult when physical examination and clinical evidence alone are employed.

Hellman and Simon, in 1935, collected 311 cases of abdominal pregnancy from the literature. We are able to find 42 additional cases reported during the last six years. Of this number, only 16 had been examined roentgenologically, a correct diagnosis being made in 7 instances, or 43 per cent.

Bermann, in 1925, is credited with being the first to use hysterography in the diagnosis of abdominal pregnancy. Since then Sarkar, Greenhill, Friedman, Polowe, Harris, and others have reported cases diagnosed by this method.

Fig. 1. Case 7: Abdominal pregnancy. Hysterogram showing fetus outside the uterine canal.

Fig. 2. Intra-uterine pregnancy. A. Uterine shadow. B. Opaque medium passing between wall and membrane.

While hysterography has given valuable information in the diagnosis of abdominal pregnancy (Fig. 1), it has been accompanied occasionally by certain undesirable complications, and for this reason means have been sought to replace the method, at least in part, with a safer one. This has led to uterine soft-tissue studies, the importance and technic of which have been

[1] From the Department of Radiology, Charity Hospital of Louisiana at New Orleans. Accepted for publication in July 1941.

Fig. 3. Case 10: Lateral soft-tissue film. A. Abdominal wall. B. Fetal skull.

Fig. 4. Case 10: Soft-tissue film. Fetus high in abdomen, absence of uterine shadow, and abnormal position of fetus.

explained by Snow and Powell, and Brown and Dippel.

At Charity Hospital, in New Orleans, there have been about 25,000 deliveries during the past five years, of which 10 (0.04 per cent) were proved cases of abdominal pregnancy. Of the 10 patients, only 7 were examined by roentgen rays, and in 2 of these only flat films of the abdomen were made; the remaining 5 were examined by soft-tissue studies and hysterograms. In only one case (No. 6 in the table) was a soft-tissue study alone made. A preoperative diagnosis, confirmed by operation, was made in all 5 cases; obviously the flat films made in the other 2 cases of this series (Nos. 1 and 4) were of no help in diagnosis. In the 4 cases in which both methods were used (Nos. 3, 7, 9, and 10), a hysterogram was made only after we were reasonably sure, by a diagnostic criterion to be described later in this article, that the fetus was extra-uterine.

There were no abortions following the injection of the opaque media into the gravid uterus, though the method has produced abortion in many reported cases. In spite of the value of hysterography in the diagnosis of abdominal pregnancy, its use is limited by this danger. Also, it can be used only in certain cases. For these reasons we hope that, with soft-tissue studies alone and certain diagnostic criteria, we will only occasionally require this method in our examinations.

In intra-uterine pregnancy the soft-tissue roentgenograms show the fetal parts to be located within the uterine shadow, and an opaque medium is often shown to have passed between the uterine wall and the membranes (Fig. 2). This upward extension depends upon the amount of pressure used.

In abdominal pregnancy the diagnostic criteria we found most useful were the following:

(1) Absence of a uterine shadow without the use of an opaque medium.
(2) Fetus usually high in the abdomen.
(3) Abnormal position assumed by the

TABLE I: TEN CASES OF ABDOMINAL PREGNANCY

Case No.	Patient	Age	Duration of Pregnancy	X-ray Examination	Diagnosis	Outcome
1	H. J. 3/8/36 (colored)	36	5 mo.	Only flat film of abdomen	Made at operation. Stillborn fetus delivered (5 mo.)	Died
2	B. M. 5/15/37 (colored)	28	8 mo.	None	Made at operation. Stillborn 6-pound fetus	Died immediately after operation
3	J. M. 3/8/39 (colored)	29	6 mo.	Soft-tissue films and uterogram	Made preoperatively by x-ray; confirmed by operaton. Stillborn fetus (6 mo.)	Recovered
4	B. P. 3/23/39 (colored)	31	9 mo.	Only flat film of abdomen	Not made until autopsy	Died. Ruptured uterus found at autopsy
5	E. M. 5/9/39 (colored)	33	5 mo.	None	Made at operation. Stillborn fetus (8 cm.)	Died three days postoperatively
6	O. B. 6/19/39 (colored)	42	9 mo.	Soft-tissue films showed abdominal pregnancy	Made preoperatively by x-ray; confirmed by operation	Uneventful recovery
7	M. T. 7/17/39 (colored)	31	9 mo.	Soft-tissue films. Diagnosis confirmed by uterogram	Positive preoperative x-ray diagnosis; confirmed at operation. Full-term normal living infant	Uneventful recovery
8	P. D. 7/27/39 (colored)	30	8 mo.	None	Made at operation. Stillborn fetus and placenta delivered	Uneventful recovery
9	A. B. 8/16/40 (colored)	30	7 mo.	Soft-tissue films. Diagnosis confirmed by uterogram	Made preoperatively by x-ray; confirmed at operation. Stillborn fetus (7 mo.)	Uneventful recovery
10	V. C. (colored)	32	6 mo.	Soft-tissue films. Diagnosis confirmed by uterogram	Made preoperatively by x-ray; confirmed at operation. Stillborn fetus (6 mo.)	Uneventful recovery

fetus. In all of the cases here reported there was a transverse presentation. In 15 of the 16 cases collected from the literature in which the x-ray was used for diagnosis the fetus was transversely placed. The other case, reported by Greenhill, showed a vertex presentation.

(4) In the lateral view of the abdomen the fetal parts are just beneath the abdominal wall, as demonstrated in Fig. 3. (It is essential to note that this sign is of importance only if a straight lateral roentgenogram is made.)

(5) A roentgenogram of the abdomen, after the injection of an opaque medium into the uterine cavity has shown the fetal parts to be outside of the uterine shadow, definitely establishes the diagnosis of abdominal pregnancy. In one of our cases we were unable to fill the uterine cavity with the opaque medium due to a uterus retroflexed and fixed to the lateral pelvic wall, as found at operation (Case 10). In this instance the diagnosis was made only on soft-tissue film studies, as shown in Figs. 3 and 4.

All of the 10 cases reported here occurred in colored patients. The average age was thirty-five years, and in each instance there was a history of previous normal pregnancy. The maternal mortality in the series was 40 per cent. All of the fetuses were stillborn with one exception, a full-term normal living infant delivered at operation (Case 7).

In conclusion, a few words about technic may not be amiss. It has been our custom in cases of suspected extra-uterine pregnancy to make 2 soft-tissue views of the abdomen, one anteroposterior and one

lateral. The films should be of good quality, showing detail and contrast, and a Potter-Bucky diaphragm should be used. The patient should be prepared by the administration of an enema, and the bladder should be empty, as a full bladder may cast a shadow which might be mistaken for a uterine shadow.

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Star-Shaped Radiolucencies of Gallstones: A Rare Roentgen Sign[1]

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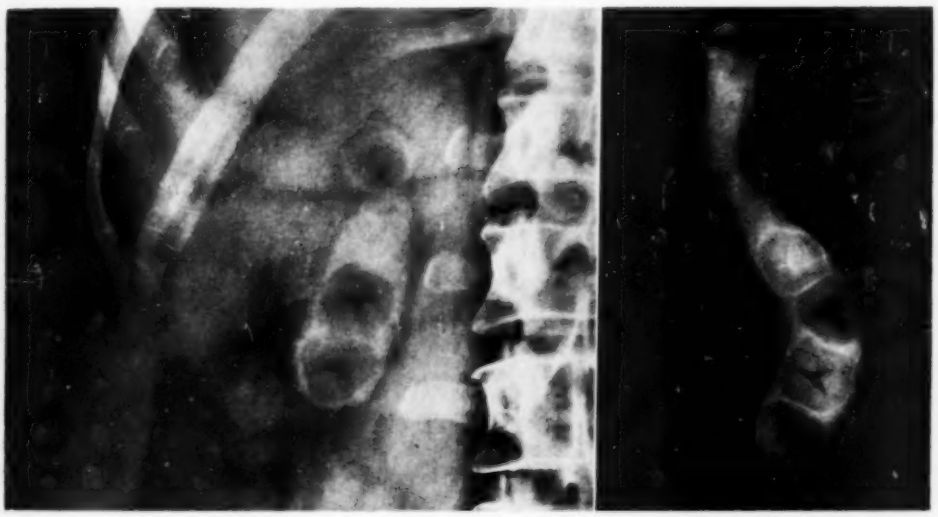
CENTRAL STELLATE fissuring has long been recognized in certain gallstones removed at operation or postmortem, but it was not reported in the roentgen film of the living until Bela Breuer (3) published his article in 1931. Åkerlund (1) in 1938, and Kommerell and Wolpers (7) in the same year, discussed Breuer's sign and its etiology rather fully. The only reference to the subject found in English is in Evarts Graham's review of Åkerlund's paper in the 1939 *Yearbook of General Surgery* (6).

Although cholecystography, since its introduction in 1924 by Graham and Cole, has revolutionized the diagnosis of gallbladder disease, cases still occur in which stones remain invisible and the dye fails to enter the gallbladder—according to Shanks, Kerley, and Twining (10) about 50 per cent of cases—usually because of cystic duct obstruction. Any sign, however rare, which will distinguish these pathological failures of visualization from the functional ones is of definite value in a field of diagnosis where the "typical" history is frequently missing.



Figs. 1 and 2. Roentgenograms of gallbladder before (left) and after (right) cholecystectomy. The preoperative roentgenogram, showing the dye-filled gallbladder, with 3 negative stones with star-shaped central translucencies, was taken Nov. 15, 1940. The roentgenogram of the excised gall bladder was taken immediately after operation, on Dec. 19, 1940.

This combination of factors is well illustrated by the following history.

E. P., a woman of 39 years, seen first by one of us in November 1940, gave a history of vomiting for eleven years, from the time the oldest of her two children was two years of age. For the past five years vomiting had occurred four or five times a week, usually in the morning, on first awakening. It was accompanied by gagging, relieved by bringing up "small to large" amounts of bile-tinged fluid,

[1] From the Departments of Internal Medicine and Roentgenology, Women and Children's Hospital, Chicago. Accepted for publication in April 1941.

Fig. 3. Gallstones. The sectioned stone in the inset occupied the open position. The right hand stone was the one nearest the cystic duct at the time of operation.

often containing flecks of blood. A headache might or might not accompany these bouts, which lasted half an hour to an hour. When these symptoms were absent, the patient had occasionally, out of curiosity, investigated the stomach content by inducing vomiting and had "never found bile."

A sense of epigastric pressure, described as a "cocklebur," had lately recurred in the morning, before breakfast, and at other times in the mid-morning or mid-afternoon. This was relieved by heat or hot milk. Attacks of sharp epigastric pains, rather fleeting, had occurred twice at night. Early in 1939 a fever of 103° was accompanied by "albumin in the urine, high blood pressure and anemia." In the fall of 1940 another short attack of unexplained fever had occurred, the temperature rising to 101°. No chills nor jaundice had been present. The appetite was good. There had been a weight loss of about 4 lb. in recent years. Headaches of great severity, incapacitating the patient for twelve to twenty-four hours had recurred at monthly to tri-monthly intervals for years. Her mother had suffered from similar headaches.

The history, rather difficult to obtain, was in other respects essentially normal and gave the impression of a sensitive, energetic woman, busy with home and professional cares, who was anxious to be rid of symptoms which interfered with efficiency and were too persistent to overlook. She was apologetic at appearing "neurotic" and stated that this was her last try at finding out what was wrong. She had sought the aid of many physicians, who had "studied her from head to foot." A gallbladder film in 1933 had been disregarded by one of them, though dye had failed to enter the gallbladder.

The physical examination was normal except for slight epigastric tenderness. All other tests made were normal.

The only positive diagnostic aid obtained was a striking cholecystographic roentgen film (Fig. 1), in which three stellate central radiolucent shadows within three large negative shadows of gallstones were seen in the dye-filled gallbladder. The clinical diagnosis was: (1) cholelithiasis; (2) migraine.

At operation, the gallbladder was found to contain four stones of approximately the same size (Fig. 2), three of which exhibited the radiolucent star-shaped centers seen in the cholecystogram. One of these stones, bisected (Fig. 3), shows the empty star-shaped central space. The stone nearest the duct showed stellate radio-opacity (Fig. 2) immediately after operative removal of the gallbladder. This stone, though not seen in the cholecystogram, may have been lying in a lower position—second from the duct (Fig. 1)—at that time. A month after operation this same stone exhibited radiolucency (Fig. 4) due, no doubt, to air-drying of the previous fluid-containing space.

The detailed history of the study of fissuring in gallstones is gathered from the writings of authors too numerous to mention here. Walter first pictured gallstones with central fissures in 1796, and Bramson, in 1846, first theorized as to the etiology of fissures. In 1892 Naunyn measured the fluid content and found it as high as 0.5 c.c. in one of his stones. He reported its rapid evaporation, its alkalinity, its traces of calcium, cholesterin, and sodium chloride, and absence of albumin. Solid masses of calcium-pigment have been found within these fissures (4), but most authors describe this pigment as only tapestrying the walls of the crevices (7). Occasionally they are filled with a cholesterin mash. Early observers believed the stellate spaces without fluid to be vacuums. Others assumed they were air-containing due to *extra vitam* drying. Åkerlund and Kommerell demonstrated that these stones floated on bile and fluids of even lower specific gravity than bile. It remained for Kommerell to prove that they contained gas, when Lohman and Petrovicki (7) analyzed the odorless gas that escaped from fresh stones broken under water; 6–7 per cent was carbon dioxide and 0.5 per cent was oxygen. No further combustible gas was present, and the remainder was nitrogen. Each stone contained as much as 40–60 c.mm. of gas.

Conjecture as to the etiology of central fissuring in gallstones has been rife since

Fig. 4. Roentgenogram of stones one month after operative removal. The right-hand stone lay at the duct end of the gallbladder. It now, in contrast to the film taken immediately after operative removal (Fig. 2), exhibits radiotranslucency. This is no doubt due to air-drying and replacing of the fluid it formerly contained by air.

Fig. 5. Roentgenogram taken in 1933, showing three stellate areas of translucency below the 11th rib, in the gallbladder area. The gallbladder failed on this occasion to fill with dye, in contrast to our experience over seven years later.

Bramson's time. Most authors seem to agree that in some way shrinking processes are involved (5). K. H. Bauer (2) developed an interesting theory in connection with his able study on autofragmentation of gallstones *in vivo*. It is based on principles of crystallization and colloid phenomena and of lines of force in pyramidal and cube-shaped stones. Delario has stressed the factor of rate of crystallization as of some significance in fissure formation. The latest theory is that of Kommerell, who suggests that gas is formed actively in certain gallstones subject to fissuring, perhaps due to bacterial activity or organic decomposition. He was unable to grow bacteria from these spaces, but feels that this idea fits in with Aschoff's and Naunyn's belief that the cholesterin-calcium-pigment stones depend on bacterial invasion of the gallbladder. He suggests that active and continuous gas formation is primary in gallstones and that the fluid fills in secondarily when active processes cease.

Whatever will be the final outcome of the studies on etiology of fissuring, some facts have been well established by observers of large numbers of gallstones. Adopting Aschoff's classification, Torinoumi (11) showed that 70 per cent of gallstones are of the cholesterin-calcium-pigment type. It is known that fissuring occurs most frequently in this type of stone and very rarely in pure cholesterin and pure calcium-pigment stones, and practically never in the fresh pure earthy pigment stone. Cholesterin crystallization, which is radial, in conjunction with the central collection and outward diffusion of calcium-pigment, seems to favor fissure formation. The stellate fissures are widest centrally and radiate like points of a star (Fig. 3) to the periphery (8), often perpendicularly to the midpoints (2) of the sides. Commonly three points, though often more, can be seen in the sectioned stones. Usually either fluid or gas fills the stellate spaces. When fluid is present, radiolucency is *absent*, because the specific gravity of the fluid is greater than that of the neighboring cholesterin material. As a rule, the entire stone remains "negative" to x-rays, but occasionally the fluid-filled central fissures are radiopaque, as is demonstrated in the top stone of Figure 2, in one of the stones in Kommerell's (7) gallbladder film of his first patient, and in Phemister's (8) Figure 16. Occasionally a core of calcium-pigment is present, which may also be

radiopaque (9). When gas (or air) fills the stellate fissures, the translucent star sign of Breuer may appear. When our patient was studied cholecystographically elsewhere in 1933, and her gallbladder failed to fill with dye, this sign furnished the only positive evidence of gallstones (Fig. 5).[2] In reviewing 655 consecutive cholecystographic films, the authors have noted the translucent star sign in but a single case.

SUMMARY

Attention is called to the rare roentgen sign of star-shaped translucency in gallstones, to which Bela Breuer first drew attention in 1931.

This sign depends on central stellate fissuring, which has long been known to physicians studying gallstones removed at operation and autopsy.

Central stellate fissures are usually filled with gas or fluid. The former gives radiolucent, the latter may give radiopaque shadows on the roentgen film.

If gas formation were very common in gallstones *in vivo*, it would seem that it should be seen more often in the roentgenogram. Technical difficulties, no doubt, account to some extent for its rarity.

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[2] Film kindly loaned the authors.

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Relation of Density of Cholecystographic Shadows of the Gallbladder to the Iodine Content[1]

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Acknowledge of the ability of the gallbladder to concentrate bile containing tetraiodophenolphthalein has long been recognized as being of clinical value. It is well known that the visualization of the gallbladder on the x-ray film depends upon a certain quantitative amount of iodine being present within it. In the absence of thickening of its walls, the shadow of the gallbladder can rarely be distinguished in a roentgenogram. As iodine-containing bile is concentrated within it up to a certain point, the gallbladder outline becomes visible as an area of increased density. In this work an attempt was made to determine the minimal amount of iodine per gram of bile necessary for visualization of a human gallbladder of average diameter. Standards were also constructed, after the manner of Newell (1), to study the validity of the use of the water phantom in an endeavor to simulate clinical roentgenographic conditions.

Four grams of sodium tetraiodophenolphthalein were administered orally to a series of 14 patients on the day preceding cholecystectomy. A film was made the next morning, from fourteen to sixteen hours later, just prior to operation. An average time of one hour elapsed between the time the film was made and the time the abdomen was opened. At operation, in some cases the bile was first aspirated through a large gauge needle and then the gallbladder was removed. In most of the cases, the bile was obtained after the gallbladder had been excised.

While there may have been some loss of gallbladder contents because of struggling in the early stages of the anesthesia, this could not influence the tests, since it would only decrease the total amount of bile and would not affect the concentration. It was realized that some change in the concentration of the dye might occur as a result of physiological activity of the mucosa of the gallbladder in the interval between the taking of the film and the removal of the gallbladder, but this possible source of error could not be avoided. In the average case, the change in concentration in such a short interval would hardly be significant. Therefore, since the patient fasted in the interim, it may reasonably be assumed that the iodine content of the bile at the time of operation was approximately the same as at the time of the x-ray examination.

The iodine content of the bile was then determined by the method of Kendall (2), in which the organic matter is destroyed and the iodine is retained as sodium iodide. Determinations were also made on the bile of three patients to whom no dye had been given.

The x-ray films taken on each patient were studied and each film was placed in one of four groups, varying from non-visualization to very dense shadows (0 to 3+). The results of the iodine assays were then compared to the groupings made.

As is shown in Table I, up to 1.062 mg. of iodine per 1 gram of bile (0.1 per cent) failed to give a discernible shadow on the film. In one patient with very faint visualization the assay showed 2.929 mg. of iodine per 1 gram of bile (0.29 per cent). Above this figure, however, definite recognition of the gallbladder outline was constant. The higher concentrations, of course, gave the densest shadows.

Although the series was small and there was a comparatively large gap between the concentration of 1.062 mg. of iodine per

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TABLE I: CORRELATION OF DENSITY OF SHADOW WITH CONCENTRATION OF IODINE (MG. PER GRAM OF BILE) WITHIN THE HUMAN GALLBLADDER

Control No Dye Given	No Shadow 0	Faint Shadow +	Moderate Shadow ++	Dense Shadow +++
0.1738 (0.017%)	0.499 (0.05%)	2.929 (0.29%)	3.012 (0.30%)	7.325 (0.73%)
0.206 (0.02%)	0.696 (0.07%)		3.021 (0.30%)	8.885 (0.89%)
0.591 (0.059%)	0.986 (0.10%)		3.310 (0.33%)	9.622 (0.96%)
	1.062 (0.11%)		4.369 (0.44%)	9.653 (0.97%)
			5.641 (0.56%)	
Av. 0.324 (0.03%)	Av. 0.811 (0.08%)	Av. 2.929 (0.29%)	Av. 3.871 (0.39%)	Av. 8.871 (0.89%)

gram of bile (0.1 per cent), which was not sufficient to cast a shadow, and the concentration of 2.929 mg. (0.29 per cent), which gave a very faint shadow, the occurrence of the latter on the very border of visibility made us feel that it represented close to the minimum amount of iodine per gram of bile necessary for demonstration of the gallbladder outline on the clinical film. Thus, it was concluded that a concentration of approximately 0.25 per cent of iodine in the bile is the minimum amount necessary to cast a discernible shadow on a clinical x-ray film.

To test our impressions of the shadows on the clinical films, we constructed a series of water phantom standards, similar to those of Newell. It is apparent that variations in the x-ray technic will cause a difference in shadow densities. Newell, on the basis of known data, wrote: "If we always use the same roentgen ray wavelength, then a given concentration of tetraiodophenolphthalein will always absorb a certain unchanging percentage of roentgen rays for a given depth. This percentage absorption will be independent of the total amount of roentgen rays—*i.e.*, will be the same for a heavy exposure as for a light one." Newell showed by test films that the amount of exposure and the time of development did not materially influence the gradation of contrast. Fogging, however, did interfere, so that the use of the Potter-Bucky diaphragm was imperative. Therefore, standards varying from very light to very dark could be determined for clinical use simply by varying the time factor.

In constructing his standards, Newell used a 4-inch (10-cm.) depth of water and "gallbladder technic," calling for a 4-inch spark gap. He exposed rubber bags, with a diameter of 3 cm., containing 0.25, 0.5, 1.0, 2.0, and 3.0 per cent of tetraiodophenolphthalein. The bags were attached to the bottom of an aluminum vessel by means of paraffin. By comparing his clinical film with the standards and then correcting for variations in diameter, Newell offered a quantitative estimation of the iodine content. His paper offered no proof that the water phantom approximated the absorption found under clinical conditions. Data obtained in previous work, however, especially in therapy, justified this omission.

In the construction of our standards, the present-day variations in voltage (and therefore in roentgen ray wavelength) for patients of different thickness were considered. Two patients, one 17 cm. and the other 24 cm. in anteroposterior diameter, were x-rayed. Voltages of 68 kv. and 85 kv., respectively, were used with 120 milliampere seconds at 30-inch distance. Beneath was placed an aluminum ladder (densimeter) with eight steps of 1 mm. each. A wooden box with a thin bakelite bottom was then filled with water to a depth of 17 cm. The aluminum ladder was placed under it and an exposure identical to that used for the thinner (17 cm.) patient was made (Fig. 1). The procedure was repeated with a depth of 24 cm. of water in the phantom, duplicating the exposure for the other patient (Fig. 2). All of the films were developed at the same time and those taken through the phantom and those of the patients were placed side by side and compared. Not only were the backgrounds of the same density in the

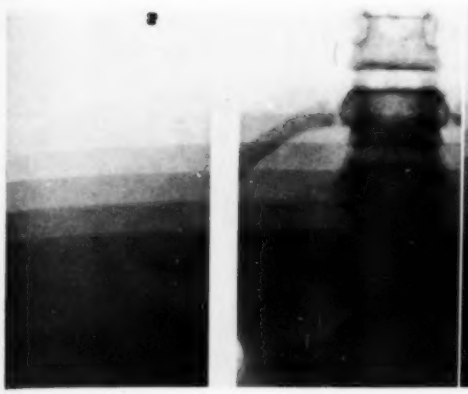

Fig. 1. Densimeter comparison between thin patient (17 cm.) and 17 cm. of water in phantom.

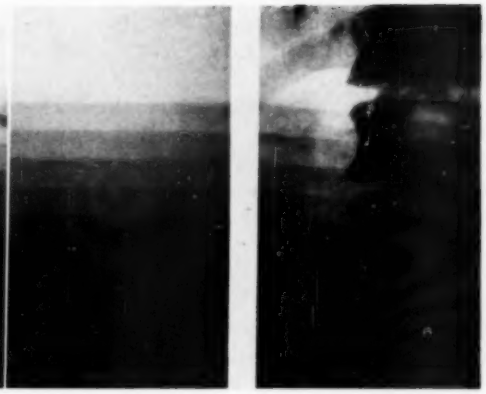

Fig. 2. Densimeter comparison between thick patient (24 cm.) and 24 cm. of water in phantom.

corresponding films but the gradations produced by the various steps of the aluminum ladder were matched throughout for the same depth of overlying absorbing material. The gradations for 17 cm., however, did not match those for 24 cm. It was therefore apparent that the water phantoms closely simulated the absorption characteristics of the human body for a given beam of roentgen rays.

Thirty cubic centimeters of bile (the average content of the human gallbladder) were placed in each of nine rubber bags. To the bile had been added tetraiodophenolphthalein in concentrations of 0.18, 0.24, 0.27, 0.36, 0.45, 0.55, 0.73, 0.91, and 1.6 per cent, respectively. Since tetraiodophenolphthalein contains 55 per cent iodine, the iodine concentrations were 1.14, 1.29, 1.53, 2.09, 2.52, 3.08, 4.14, 5.11, and 9.36 mg. per gram of bile, or 0.1, 0.13, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5, and 0.9 per cent iodine, respectively. One bag was filled with bile only. These bags were allowed to settle on the bottom of the water-filled phantom, weighted down by metal number markers. Because of the use of identical volumes in the rubber bags, which were firmly tied, the bags were almost perfectly round and identical, measuring 37 cm. in diameter.

The phantom was then filled with water up to 17, 20, and 24 cm. in depth, successively. Films were made at each of these levels with the technic which would be used in clinical radiography (Table II) for patients of a corresponding size. In order to obtain films with both light and dark backgrounds, multiple films were made at each depth of water by varying the time factor only.

TABLE II: ROENTGENOGRAPHIC TECHNIC

Film	Depth of Water	Kv.	Ma.	Time	Distance
1	17 cm.	68	10	12 sec.	30 in.
2	17 cm.	68	10	18 sec.	30 in.
3	20 cm.	73	10	12 sec.	30 in.
4	20 cm.	73	10	18 sec.	30 in.
5	24 cm.	85	10	12 sec.	30 in.
6	24 cm.	85	10	18 sec.	30 in.

When the films were viewed, it was found that the uniform background of the water phantom enabled one to distinguish a very faint outline of even the bag containing only bile. This image, however, and the images of bags containing tetraiodophenolphthalein with up to 2.09 mg. iodine per gram of bile (0.2 per cent) were so poorly visible that it is safe to say that under clinical conditions, in the variegated background of tissue and possibly intestinal gas, they could not be recognized. The bag containing 2.52 mg. of iodine per gram of bile showed a density which was similar to that cast by a faintly visualizing gallbladder. This concentration was the first one which cast a shadow that could be

fairly easily delineated. The higher concentrations of dye cast clearly visible shadows.

The phantom tests confirmed the statement of Newell, that the density of the film did not seriously affect the absorption gradient. No tests were made with different voltages at the various depths of water.

The densities of the shadows cast by the concentrations of dye in the various bags compared well with the shadows cast by the human gallbladders with comparable concentrations as determined by the Kendall quantitative method and corrected for variations in diameter.

SUMMARY

A series of patients with gallbladder disease (usually stones) were given tetraiodophenolphthalein the night before operation and a cholecystogram was made next morning just before the anesthetic was given. In some instances no shadow of the gallbladder was obtained; on other occasions shadows of variable density containing negative shadows of stones were encountered.

By correlation of these films with quantitative determinations of the iodine content of the bile obtained from the gallbladder at operation, it was found that a concentration of about 2.5 mg. of iodine per gram of bile (0.25 per cent) is necessary for faint visualization of the gallbladder. Moderate visualization of the gallbladder was obtained with an average iodine concentration of 0.39 per cent, while dense shadows were obtained with an average iodine concentration of 0.89 per cent.

By the use of an aluminum densimeter ladder, it was found that a water phantom approximates closely the absorption conditions found in the average patient during clinical radiography.

With rubber bags, 37 cm. in diameter, containing 30 c.c. of bile, to which iodine in the form of tetraiodophenolphthalein had been added in concentrations ranging from 0.14 to 0.93 per cent iodine, it was found that approximately 0.25 per cent of iodine was necessary for a faintly visible shadow to be obtained on roentgenography.

There was therefore an agreement between the two methods used in determining the amount of iodine required to produce a shadow.

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Roentgen Diagnosis of Space-Occupying Lesions in the Region of the Head of the Pancreas[1]

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THE ROENTGEN study of disease of the pancreas is difficult because the organ cannot be visualized directly and because it is one of the few in the abdomen which has not yet been made to absorb a radiopaque substance. It therefore becomes necessary to resort to indirect methods, depending chiefly on mechanical effects in the contiguous structures, notably the barium-filled duodenum or the gas-filled stomach, to detect pathological changes in this region.

In 1937, Hunt, Hicken, and Best published a paper on exploration of the biliary ducts by cholangiography during and after operation, by the injection of a contrast substance, usually through a tube. In the presence of a carcinoma of the pancreatic head there was no filling of the lower segment of the common duct, which was cut off abruptly and often in a transverse direction rather than a tapering or funnel-shaped pattern. The patent proximal portion of the common duct and the cystic duct were unusually widened. These writers also observed reflux of radiopaque material into the pancreatic duct from the ampulla in five cases, the duct being filled for a distance of 2 to 9 cm. Such reflux depends on the anatomical relation of the common duct, the pancreatic duct, the ampulla of Vater, and the duodenum, and also on the terminal sphincteric mecha-

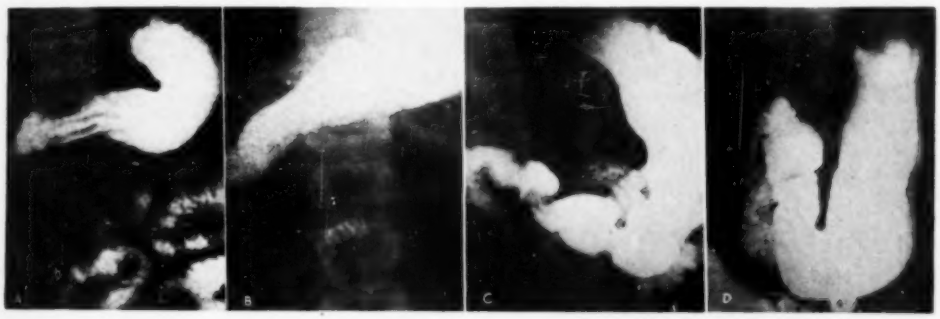

Fig. 1. Normal appearance of the barium-filled duodenal loop in the various forms of habitus. A. Marked hypersthenic. B. Moderate hypersthenic. C. Sthenic. D. Hyposthenic. Note the apparent enlargement of the duodenal loop but the absence of indentation or displacement in both instances of hypersthenia.

In 1923, Dickson described pressure deformities of the barium-filled stomach and duodenum produced by pancreatic carcinoma. In 1931, Butler and Ritvo called attention to displacement with widening of the duodenal curve as a result of pressure from a tumor of the head of the pancreas. Rigler, in 1933, confirmed the work of Butler and Ritvo and also mentioned that in carcinoma of the body and tail, the stomach was displaced upward and forward while the transverse colon was displaced downward.

In 1934, Engel and Lysholm described a method for radiological observation of the pancreas by inflation of the stomach with carbon dioxide followed by lateral prone and anteroposterior exposures. Any enlargement of the pancreas is demonstrated by the increase in the space which it occupies (by protrusion into the gas-filled stomach from behind).

[1] From the Department of Radiology, Kings County Hospital, Brooklyn, N. Y. Accepted for publication in August 1940.

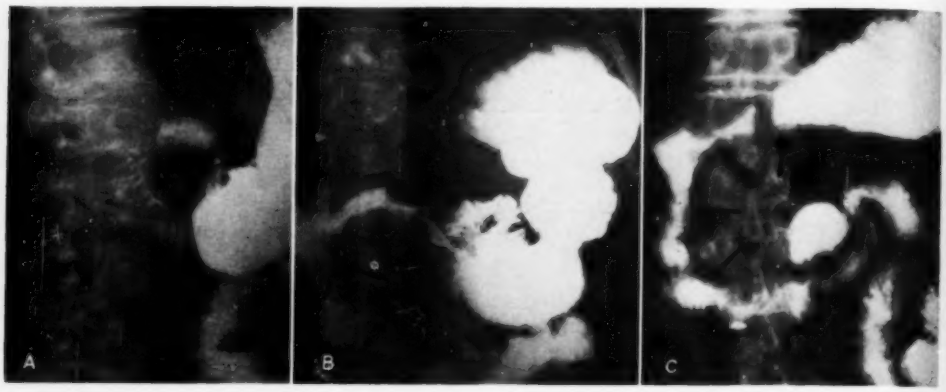

Fig. 2. Deformities of the inner concave border of the descending duodenum as produced by carcinomas of the pancreatic head. A. By a small growth, 1 1/2 inches in diameter. B. By a moderate-sized growth, 2 1/2 inches in diameter. C. By a large growth, 4 inches in diameter. In C note the diverticulum in the ascending duodenum.

nism. According to Giordano and Mann, reflux is impossible in about one-third of all subjects because the pancreatic and common ducts open separately into the duodenum.

Since our roentgenologic criteria are directly dependent on gross pressure changes, they signify simply pressure from enlargement of normal regional structures or from the formation of adventitious space-occupying masses, nothing more. They are not pathognomonic for carcinoma, but may result from any enlargement of the pancreatic head, from regional retroperitoneal lymph node enlargement, or from any retroperitoneal mass in the pancreatic area.

It has become our practice, therefore, to report simply that there is evidence of "an abnormal mass in the region of the pancreatic head," thus avoiding a specific statement of etiology. As roentgenologists viewing gross disease inferentially, that is all we have a right to report; but inasmuch as most cases will undoubtedly present characteristic clinical or laboratory findings, we may often parenthetically suggest the more likely specific etiology.

Since we have been able to demonstrate roentgenographically, and to prove microscopically, a variety of pathological changes in and around the head of the pancreas, we feel it opportune to review the criteria and to emphasize the point that with special study a causal factor can frequently be supplied for heretofore inadequately explained roentgen pressure changes.

The pancreas is an irregularly long retroperitoneal gland, lying rather transversely in the posterior portion of the upper half of the abdomen. It is 12 to 15 cm. in length, consisting of a head, neck, body, and tail. The head lies within the duodenal sweep to the right of the mid-line and is related anteriorly to the mid-transverse colon. The neck is about 2.5 cm. in length and is directed first upward and forward and then upward and to the left to join the body; it is related anterosuperiorly with the pylorus. The body is related anteriorly to the stomach; posteriorly it is in contact with the left kidney and suprarenal, while inferiorly it is related to the duodeno-jejunal flexure. The tail extends as far left as the gastric surface of the spleen.

The following signs point to the presence of a mass in the region of the head of the pancreas.

(1) Enlargement of the duodenal loop or widening of the semicircular arc described by the duodenum. It is important in evaluating this sign to exclude apparent enlargement due to a hypersthenic habitus, in which the stomach is high in position and almost horizontal, and the duodenal

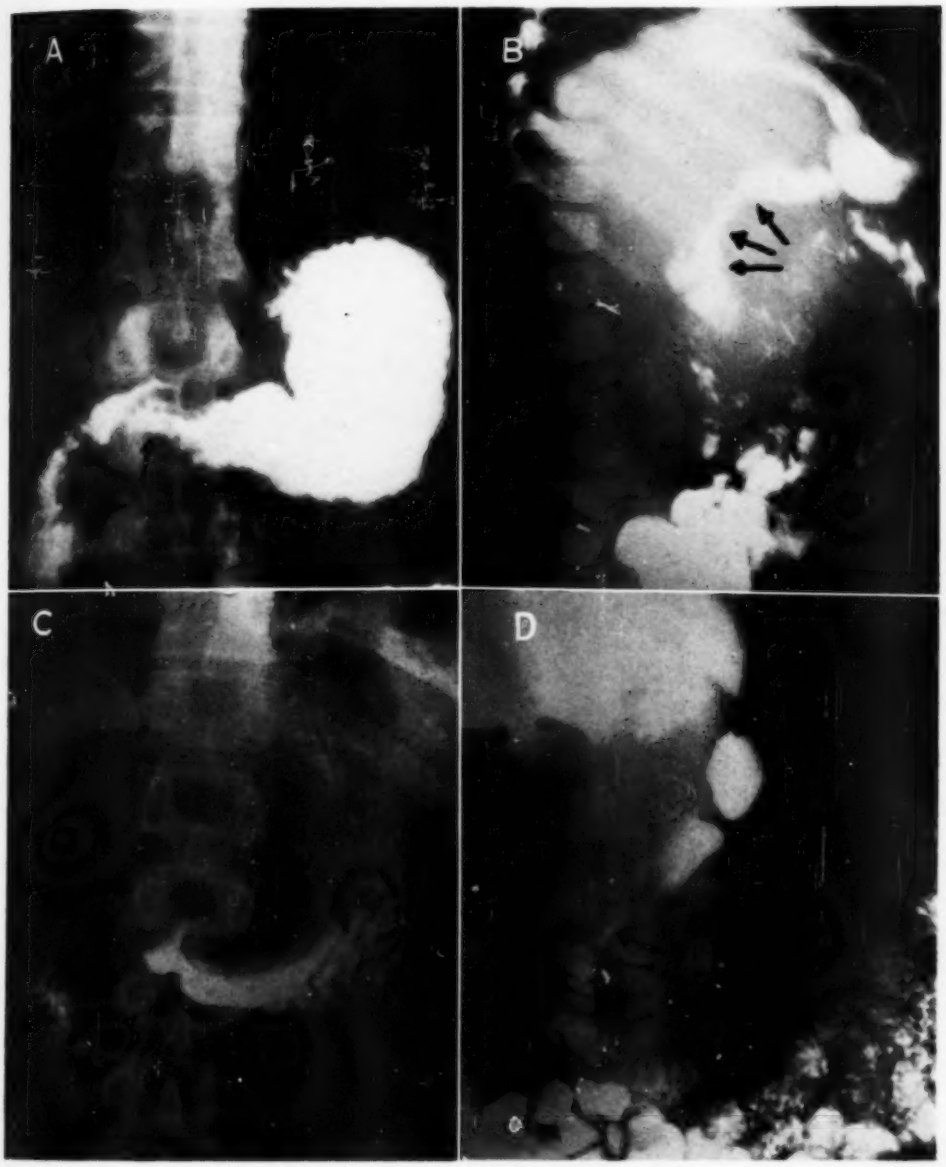

Fig. 3. Deformities of the inner concave border of the descending duodenum as produced by: A. Metastatic nodes from a gastric carcinoma. B. Metastatic nodes from a neuroblastoma of the left suprarenal gland. Right lateral view. C. Enlarged lymph nodes in a case of proved infectious mononucleosis. Heterophilic reaction positive. The enlarged nodes were absent on re-examination in four weeks and again in five months. D. Upward traction of the duodenum about the pancreatic head by a stomach herniated up through the diaphragm. Note the ulcer on the lesser curvature of the pars media of the herniated stomach.

loop is fully exposed and therefore appears to be enlarged. Enlargement alone is consequently less significant in the hypersthenic patient but very significant in the sthenic or hyposthenic subject. In the hypersthenic patient it is mandatory to

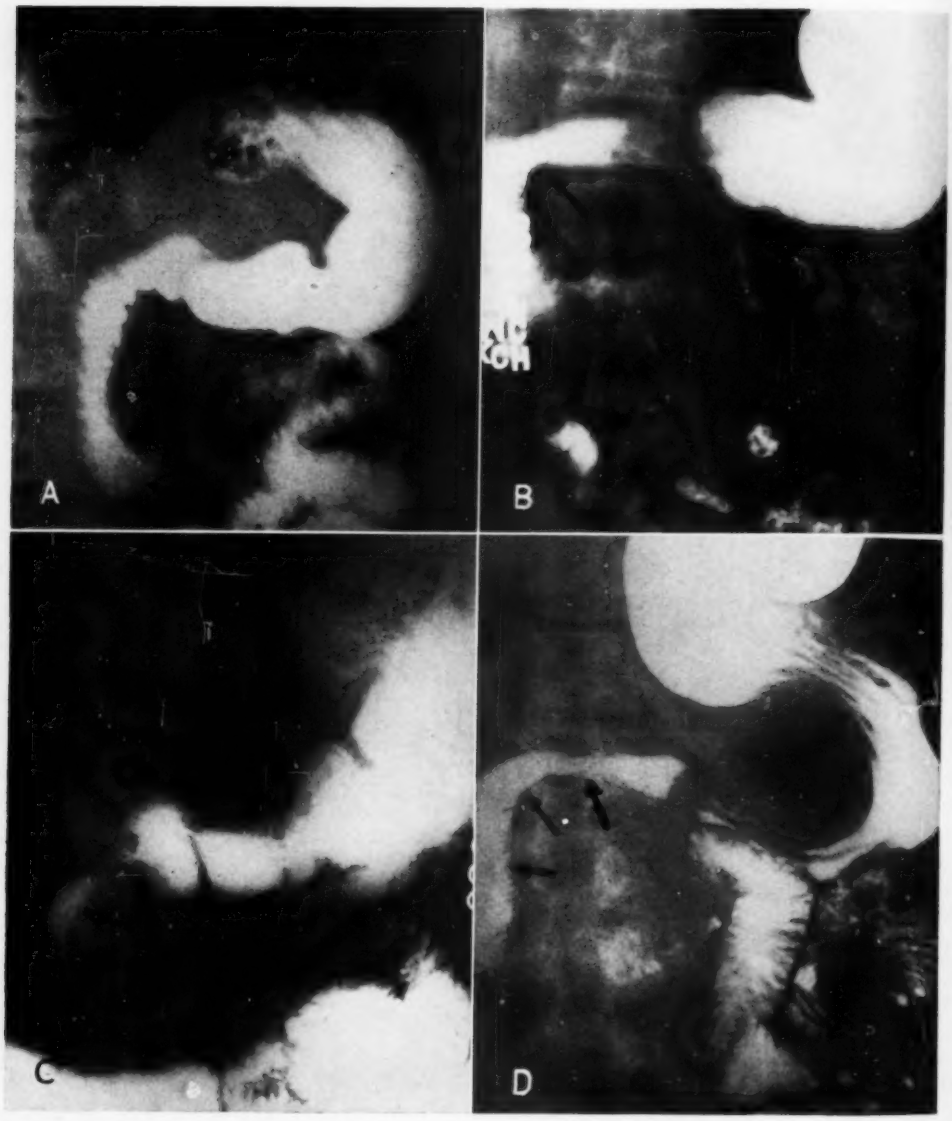

Fig. 4. Deformities of the inner concave border of the descending duodenum as produced by: A. An enlarged pancreatic head due to a chronic pancreatitis secondary to chronic gallbladder disease. B. An enlarged pancreatic head caused by cloudy swelling secondary to biliary disease. C. A cyst of the pancreatic head. D. Amyloidosis of the pancreas.

demonstrate in addition to the enlargement some evidence of extrinsic pressure on the inner concave border of the descending duodenum. This is of special importance since these patients are particularly liable to biliary and pancreatic pathology.

(2) Extrinsic pressure, by its ironing-out effect, changes the direction of the medial ends of the horizontal duodenal mucosal folds (valvulae conniventes) so that they become internally concentric with the duodenal lumen and are visualized on the film

Fig. 5. Deformity of the outer convex border of the descending duodenum caused by an enlarged gallbladder secondary to carcinoma of the ampulla of Vater.

Fig. 6. Carcinoma limited to the body and tail of the pancreas with no involvement of the head. Note the normal duodenal loop and the forward and slight upward displacement of the stomach.

as a border limiting the medial wall of the barium-filled descending duodenum; their density is directly proportional to the degree of extrinsic pressure from the space-occupying mass in the region of the head of the pancreas. This sign is an early one, seen before any enlargement or displacement takes place. With severe pressure the pattern of the valvulae conniventes may be greatly altered or even lost.

(3) Displacement of the duodenal loop toward the right and anteriorly by space-occupying masses in the region of the pancreatic head is a later sign. The displacement may be general and uniform or simply be a localized indentation on the inner concave border. The stomach may be displaced upward and forward if the lesion is large. Masses in the region of the body and tail do not affect the duodenal loop but produce downward and anterior displacement of the transverse colon and proximal jejunum and occasional upward and forward displacement of the stomach.

(4) Fixation of the duodenal loop, especially its medial wall. This may impair the normal expansion which is usually seen with the passage of increased amounts of barium.

(5) Diminished caliber of lumen, which may go on to duodenal obstruction.

(6) Alteration of peristalsis. Peristalsis may be diminished or absent or antiperistalsis may occur.

(7) Palpable mass.

(8) Downward and forward displacement of the mid-transverse colon.

(9) Extrinsic pressure defect on the outer wall of the descending duodenum from an enlargement of the gallbladder, with displacement of the duodenum medially. This finding, in the presence of a painless, increasing jaundice, is suggestive of carcinoma of the ampulla or common duct.

The most common pathological conditions in the region of the pancreatic head capable of producing identical roentgen signs in the order of importance are, in our experience:

(1) Malignant new growth of the head of the pancreas.

(2) Enlargement of retroperitoneal lymph nodes, due to (*a*) primary growth, as in lymphoblastoma, (*b*) secondary, metastatic growth, (*c*) inflammatory lesions, as in infectious mononucleosis.

(3) Pancreatitis, from simple edema secondary to biliary pathology to chronic pancreatitis with or without calculi.

(4) Other retroperitoneal tumors, such as sarcoma.

(5) Cysts of the head of the pancreas.

(6) Aneurysm of the anterior wall of the abdominal aorta.

(7) Amyloidosis of pancreas.

(8) Upward traction of duodenum, *i.e.*, secondary to diaphragmatic herniation of the stomach.

CONCLUSION

We have shown that in addition to carcinoma of the head of the pancreas, there are numerous space-occupying lesions in this region which are capable of producing identical roentgenographic signs as manifested on the barium-filled duodenal loop.

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Recovery Function of Irradiated Tissues: A Theoretical and Experimental Study[1]

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A DISCUSSION of the function of recovery of irradiated tissues must be based on a clear understanding of the relation between physically measured radiation quantities and observable biological effects and also upon a clear concept of what the terms damage and injury, recovery and repair of tissues represent physically, chemically, and biologically. These matters are here considered under four main headings:

I. Quantitative relations between physical measurements and observable changes from irradiation of biological materials.
II. Radiation effects on cells and tissues.
III. Tissue injury and recovery equilibrium.
IV. Biological action rate and cell-killing curves for various tissues.

I. QUANTITATIVE RELATIONS BETWEEN PHYSICAL MEASUREMENTS AND OBSERVABLE CHANGES RESULTING FROM IRRADIATION OF BIOLOGICAL MATERIALS

A. Definitions. (*a*) *The Absorption Law:* A homogeneous beam having the physical intensity I_0, absorbed in a material of thickness x, will emerge with the intensity I_x, and this process expressed in symbols is found experimentally to be represented by

$$\log_e I_x/I_0 = -\mu x \qquad (1)$$

In this equation, μ is the constant characteristic of the absorbing substance and the radiation. It indicates the percentage decrease of the radiation in one unit thickness of absorbing material.

A heterogeneous beam is reduced in intensity in a more complex manner. The diminution found experimentally is represented by the expression,

$$\log_e I_x/I_0 = (-\mu + 2\eta)x \qquad (2)$$

In this equation μ is the absorption coefficient, η is the heterogeneity coefficient which changes with increasing depths as the radiation is additionally filtered and homogenized in the absorbing material, and the effective absorption coefficient is given by $(-\mu + 2\eta)$ (1).

(*b*) *Ionization Measurements:* The intensity of a radiation is generally estimated by counting the number of ions produced. The charges of the ions are measured as electrostatic units, each of which represents 2.1×10^9 ions per second. A radiation intensity which produces in 1 second of time in 1 milliliter of air, under standard conditions, 2.1×10^9 ions per second, is called the roentgen (r).

Obviously, the number of ions produced in an ionization chamber depends on the fraction k of the beam that is absorbed in the air of the chamber and the constant b indicating the amount of work required to separate an electron from an atom, thereby creating one pair of ions (2). If i is the ionization current then measured, we have the equation

$$ik/b = \log_e I_0/I_x \qquad (3)$$

The value of k is fixed in the definition of the roentgen and is easily determined experimentally. The value of b is determined for air as 35 volts; its value for liquids, solids, and tissues is not known but is probably much larger. The number of ions, therefore, produced in other media is different from the number of ions produced in air; from the values measured with a small ionization chamber at various depths

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in a medium other than air, no conclusions can be drawn as to the absorption or ionization produced in that medium.

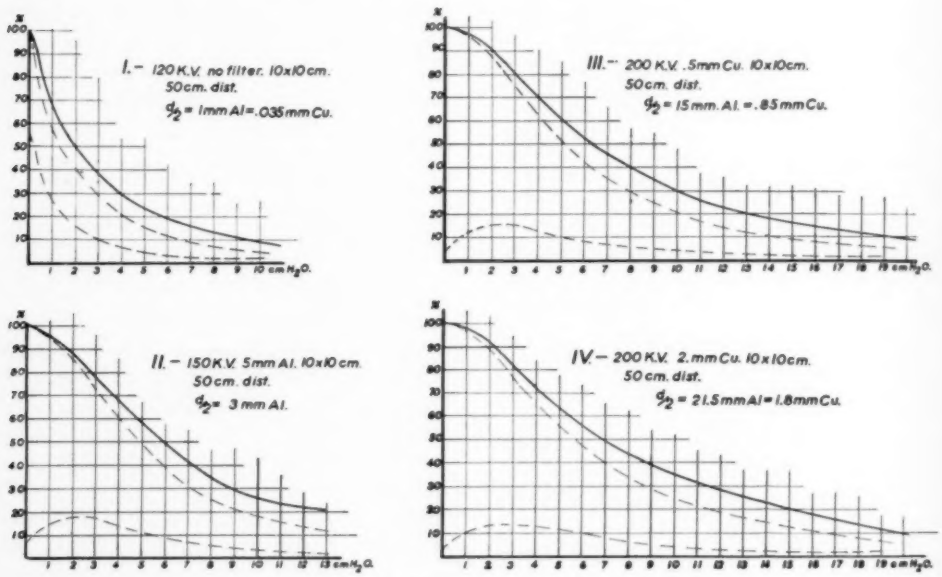
(*c*) *Biological Effects:* According to the Draper-Grotthus law, radiation absorbed in tissues is a measure of the biological effects produced. Unless this law is disproved, a measure of the ionizing power of a given radiation in air cannot be taken as a measure of its biological effectiveness in tissues.

The air ionization chamber is the most convenient device for measuring fractional intensities of a radiation beam, but absorption of radiation in tissues can be determined only by determining the change of intensity not in air but in the tissues. Thus, by differentiating equation 1 (or 2), we obtain,

$$\frac{dI_x}{dx} = -\mu I_0 e^{-\mu x} = -\mu I_x \qquad (4)$$

The biological effectiveness or the extent of absorption is thus proportional to the product of the fractional intensity reaching the level x (at which the changes are to be produced) and the absorption coefficient at the level x of the irradiated material.

B. Biological Tests: To test the above definitions, four experimental absorption curves in water were developed from measurements including the entire portion of secondary radiation from water. These represent four radiation qualities which are widely different. The quantities of each required for a skin reaction (erythema) are reasonably well known. In carrying out the transformation represented in equation 4, values should be obtained which are the same as the quantities of measured radiation required by clinical tests. Quantitative agreement would be proof of the correctness of the definition of biological response as expressed in equation 4.



Figs. 1, 2, 3, and 4. Measured data corrected to indicate biological action in the depth of tissues in terms of radiation absorbed in 1 cm. of tissue at various depths.

In Figures 1, 2, 3, and 4, the upper (solid) curves represent measured intensities in water. The second curve is corrected for decreased intensity rates. The lowest curves represent these values multiplied by the slope of the absorption curve; they

therefore show the number of roentgens stopped in each corresponding centimeter of water. These, to avoid confusion, are designated as "mass-roentgens" (m-r).[2]

The following table lists the data obtained from the absorption curves from which the mass-roentgens were calculated.

TABLE I.: DATA FROM ABSORPTION CURVES IN FIGURES 1–4

1	2	3	4	5	6	7	8	9
Curve No.	$I_{1\text{ cm.}}$, %	I_x Corrected	μ	$\mu I_x = (m\text{-}r)$	m-r Added	r/Dose Meyer-Holthusen	r/Dose Calculated	m-$r \times$ Dose / 100
I	67	57	0.43	24.5	115	350	290	72.5
II	96	94	.17	16.0	110	400	420	67.2
III	98	96.5	.13	12.5	113	550	560	70.0
IV	98	97	.11	10.0	116	700	700	70.0
					Av. 113			Av. 70.0

It is easily observed that the first curve, which represents a non-filtered radiation, bends downward from the zero-point with a rather uniform concave sweep. The other curves, representing filtered radiation, have initial short convex portions and then continue concavely in the same general direction as the first curve.

A plausible explanation may be that with non-filtered rays the secondary radiation consists mostly of characteristic or photo-radiation, provided that only low-atomic substances are irradiated. These rays are emitted from the atom in which they originate with uniform and equal intensities in all directions; thus a large component in the backward direction is largely contributory in producing the erythema reaction of the skin.

When filtered high-voltage rays are applied, the secondary radiations are nearly all recoil radiations, and of these, the directed backward components are extremely low-penetrating and quantitatively small. Thus the contributory effect in the production of the erythema reaction on the skin is relatively small until they have reached greater depths and until the ionization chamber is more completely submersed. The skin and the chamber receive the more penetrating and larger components at the lesser angles from the incident beam.

Since the thimble type ionization chamber never measures the very low-penetrating components, it is not feasible to say that the bent portion of the curve represents the true and full intensity of the secondary radiations produced.

The second column of Table I shows surface intensities measured as per cent of primary radiation intensity at 1 cm. under water. The chamber nearest the surface was half submersed and thus the actual superposed water layer was less than 1 cm. From the 3rd or 4th cm. on, however, the discrepancies are probably negligible. In the third column of the table are listed the corrected intensities obtained from the data for the number of roentgens required for equal skin reactions with varying intensity rates (Meyer-Holthusen, 3). The fourth column gives the linear absorption coefficients for each radiation at the 1-cm. level; these are calculated as the differences between the natural log of the surface intensity and the intensity at 1 cm. and thus for 1 cm. thickness. The fifth column gives the product of the factors from columns 3 and 4. These are the mass-roentgens absorbed or stopped in the first centimeter of water if 100 roentgens are applied to the surface. The calculation of

[2] According to the second law of motion, a force F is defined as that which changes the motion of a mass m to an acceleration a. Thus $F = am$. If all factors are unit value, we have unit of force. In radiation problems the analogue to force is absorption μ and to mass the measure of the intensity I_x. The product of these is equivalent to the force of radiation or to dI_x/dx; hence, $dI_x/dx = \mu I_x$. By the definition of the roentgen, the factors are unit values (1 c.c. of air, 1 e.s.u.), and because of the similarity of radiation force with mechanical force, the term mass-roentgen is used.

the mass-roentgens can also be carried out for the lower depths of water. The result of these calculations is plotted in each of the figures presented by the curve nearest the abscissa lines.

In column 6 are listed the sums obtained by adding the mass-roentgens in all layers until the radiation intensity transmitted to lower layers is negligibly small. The average of these additions is 113. If no radiation had escaped the absorbing material and if no secondary radiation had been formed, the expected value would be 100. According to Crowther (4), Hewlett (5), and Kirchner (6), however, if substances of low atomic weight are irradiated, the total secondary radiation formed is in close proximity to 20 per cent of the primary radiation. When a small portion of the radiation escapes on the exit side, and also when some of the radiation is lost from the surface layers, it is found that the experimental average of 113 against the theoretical 120 is within normal expectance.

In column 7 of Table I is given the number of roentgens required for equal erythema doses on the skin for the four types of radiation chosen, as taken from the Meyer-Glasser curve (7). For example, taking the mass-roentgens absorbed in the first centimeter of water as biologically actinic, then, when 100 roentgens are applied to the surface, 10 mass-roentgens are absorbed in the first centimeter with radiation type IV. If, however, 700 roentgens are applied to the surface of the skin, as for an erythema dose, then it is concluded that 70 mass-roentgens are responsible for the erythema reaction. With other types of radiation it is possible to calculate the total roentgens absorbed in the first centimeter, which by comparison with the *m-r* values in columns 8 and 9 produce equal biological effects. These values are listed in columns 8 and 9, respectively, as the calculated r/dose and as total *m-r*'s required for equal effects of the erythema dose. It is assumed that for the production of visible biological changes the radiation stopped in 1 cm. of water is an equivalent measure of the biological reaction.

These correlations of mass-roentgens as calculated from the experimental data and producing a visible biological change support the validity of the Draper-Grotthus law. They also support the hypothesis that the biological effects are evaluated by equation 4.

C. Discussion: Results obtained by Packard (8) with Drosophila eggs submersed in water are in agreement with the above data. He found the intensity, measured biologically, at 3 cm. below the surface of the water, to be 21 per cent greater than that of the incident beam. With 120 kv., 0.25 mm. Cu + 1 mm. Al, and 30 cm. distance, the biological effect in the first 5 cm. below the surface of the phantom was found by him to be decidedly greater than previously reported. He considers the lack of agreement between the results of different investigators as due to differences in the measurement of scattered radiation. While his conclusions are partly supported, and confirmed, his observations are fully in accord with equation 4. The agreement of his results at depths below 5 cm. with other results obtained by physical measurements is due to the fact that initially in the calibration curve measured roentgens were compared with the percentage survivals of Drosophila eggs.

Results in good agreement with the data set forth in Table I were recorded by Hudson (9), who found the variation of biological actinity with radiation quality represented in the Meyer-Glasser curve. In addition he calculated the mass absorption coefficients and the absorption in the first millimeter of skin from the average wavelength of various radiation qualities. He found this to average 17 roentgens and concluded that "the total energy absorbed in the superficial layers of the skin is practically constant."

D. Conclusions:

1. Ionization in air, in other gases, in liquids, and in solid materials is unequal.

2. The factors of proportionality are the linear absorption coefficients.

3. Biological effectiveness of measured roentgens is proportional to the radiation

absorbed in 1 cm. of tissue, *i.e.*, the measured intensities multiplied by the absorption coefficient or the mass-roentgens.

4. Summing up the mass-roentgens gives the theoretical value of 120 mass-roentgens with secondary radiation, when the equivalent of 100 measured roentgens without secondary radiation is applied to the surface.

5. Radiation absorbed in the surface layer, *i.e.*, in the first centimeter of tissue, to produce an erythema reaction is constant for various radiation qualities and equal to about 70 *m-r*'s.

6. Filters decrease the formation of characteristic secondary radiation in tissues and water.

7. Recoil or scattered secondary radiation, having a smaller backward component, decreases the effectiveness of the applied radiation on the skin.

II. RADIATION EFFECTS ON CELLS AND TISSUES

The Draper-Grotthus law is generally accepted as the basis for the biological action of radiant energy. It states (and some specific evidence in support of it is presented above) that only the absorbed radiation is actinic. It seems to be most desirable, therefore, that the radiation be absorbed as strongly as possible in the tissues constituting the lesion to be treated; but, as a consequence of the strong absorption, the penetrative properties suffer. High penetration, however, is required to penetrate normal overlying tissues and to reach the more deeply located parts of the lesion. These two requirements, which are opposite in character, bear on the selection of the optimum penetrative properties for a given lesion. The determination of this optimum is evidently the fundamental problem of the therapeutic application of short wavelength radiation.

A. Physical Aspect: From the rather extensive clinical material already accumulated, no concise statement as to the mechanism of action of rays on tissues has thus far been derived. The general impression is that the reaction of tissues to radiation is complicated by side effects and secondary reactions that influence the ultimate result.

The first physical action of rays is upon the atoms, irrespective of their state of combination. The atoms are converted into ions and in that state they interreact chemically with other ions or colloids depending on the chemical reaction of the cells, tissues, and fluids. The final equilibrium, in so far as chemical and colloidal components are concerned, is expressed by the law of Mass Action Equilibrium. But, in so far as living tissues are concerned, function of recovery and repair may alter or even completely undo radiation effects according to the conditions existing. Some of these conditions are considered in the following paragraphs.

B. Biological Aspect: The smallest composite unit of living tissues is the cell. Hence it is in the cell that the immediate biological effects of irradiation are manifested. The impact of a photon upon one of the electrons of an atom in a cell may cause the production of one pair of ions; this constitutes the immediate product of the action of the rays. It is, however, necessary to determine whether or not one pair of ions produced in a cell is sufficient to cause the death of the cell. We thus have the single-hit and the multiple-hit theories of the death of a cell.

By far the greater amount of evidence is in favor of the multiple-hit theory (10). This fact makes it evident that there are preliminary stages of injury to a cell before its death occurs. Experimental evidence shows that 30 to 50 hits are necessary for a lethal dose for a normal adult cell in human skin.

It is improbable, however, that all cells even in the same tissue are biologically equal. It is known that tissue cells do not exist singly but that they combine to form cell complexes and various organs. It seems improbable, therefore, that an exact relationship between the number of hits and the exact extent of biological injury to a cell can ever be exactly determined.

C. The Latent Dose: The injury caused

by the production in a cell of one pair of ions is evidently of exceedingly small magnitude and, as stated, a large number of such ions must usually be produced in a cell to cause its death. It follows, also, that many intermediate stages of injury exist before a lethal effect of the cell has accrued. Quantitative cell-killing experiments indicate that unless a full lethal dose for the cell is given, the cell will usually recover with repair of the sub-lethal injury caused by the radiation. Recovery from sub-lethal skin damage, as estimated from the data of Reisner (11), is said to take place in about twelve hours. On this basis, it should be possible to administer a sub-lethal dose every twelve hours for an unlimited number of times without causing a lethal effect on the cell; it is not possible, however, to repeat such doses without limitations. A fatigue of the tissues is discerned from about the eighth repetition of irradiation. The doses causing sub-lethal injury gradually become smaller as the number of irradiations is increased.

The effect of irradiation on tissues is analogous to the process of generating steam by heating water in a boiler. If the boiler is heated with a small flame, or over a small area, a larger amount of heat will be lost by cooling than when the boiler is heated with a large flame or over a large area. Moreover, every time we allow the water to cool by interrupting the process of heating, enough heat must be applied to bring the water again to the boiling point. The total quantity of heat required for producing a certain quantity of steam depends, therefore, on the size of the flame, the size of the heated area, and the number of interruptions in the process of applying the heat. The recovery of cells from the effects of irradiation corresponds to the loss of heat from the boiler due to cooling.

D. The Value of the Latent Dose: From reliable data involving visible reactions the value of the latent dose can be determined. The correctness and consistency of the above theory may thus be tested. The data of Holthusen (12), Meyer (3) and Gregori (13) are suitable for this purpose. If we plot the logarithm of the intensity rate variations against the logarithm of the total quantity of roentgens required for uniform and equal effects (Fig. 5), we obtain from the data of Holthusen and Meyer (14) curves I and III for equal erythema reactions with single applications of various intensity rates. Curve II, from Gregori's data, shows equal percentage survivals of Drosophila eggs with single applications and varying intensity rates. These three curves (Fig. 5) are straight lines having the slope 4.7; this indicates that there is no so-called constant term involved.

Other pertinent data are published by MacComb and Quimby (15), Miescher (16), Reisner (11), and Meyer (3). These are for equal skin reactions, but while the area and intensity rates were maintained constant, the application was interrupted. This necessitates considerably larger quantities of total radiation for equally effective doses. Bent curves arise from plotting the logarithm of these relations. This suggests that a constant term is involved in the reaction. This constant term can be found by the trial and error method of subtracting various constant values from the single applications until with the appropriate constant the curves are substantially straight lines.

Because in interrupted irradiation erythema reactions on the skin are not very sharp or precise, it might be anticipated that these curves are less accurate than those from the former data. But the value 130 roentgen-minutes, if subtracted as a constant term, makes curves IV, V, and VI quite straight, as might be expected; their slope is also 4.7, indicating that the value of the constant term for highly filtered radiation on the skin is 130 roentgens.

While the value of the latent dose for normal adult skin with highly filtered 200 kv. radiation is 130 r, it must be borne in mind that for more highly sensitive tissues, such as the lymph cells, the lymph, embryonal and transitional tissues, the latent dose is about one-third of 130, or 45 roentgen-minutes. For other tissues of

less sensitivity, such as the embryonal tumors, myelomas, etc., this dose would be about half to three-quarters of 130, or from 70 to 100 roentgen-minutes. For young and growing tissues the latent dose would be from 100 to 130 and for all less sensitive tissues it would be greater than 130 roentgen-minutes (3, 17).

E. Mathematical Formulation: The actual existence of a latent dose is brought into evidence by many experimental curves (Glocker, 18; Packard, 19; Faber, 20; Moppett, 21) which demonstrate a latent period before any visible biological effects of the irradiation make their appearance. To express this relation more precisely, we can designate by r_s the roentgens of each single and constantly applied quantity of radiation; r_b designates the biologically active portion which is responsible for visible tissue changes; and r_l, the latent portion which causes sub-lethal cell injury (from which the cells may recover completely when sufficient time is allowed between applications). Thus we obtain

$$r_s = r_b + r_l \tag{5}$$

In the same sense, the total (measured) roentgens administered in n single portions, *i.e.*, with $n - l$ interruptions, will be

$$r_t = nr_s \tag{6}$$

From 5 and 6 we obtain,

$$r_b = n(r_s - r_l) \tag{7}$$

and

$$r_b = r_t - nr_l \tag{8}$$

As has already been stated, the value for the latent dose is not constant, but it decreases when the number of interruptions exceeds a certain total. Moreover, the value for the normal skin, $r_l = 130$ roentgen-minutes, is a statistical result, determined as an average. The physical process involved is such that from the moment the irradiation starts, there are a few cells actually killed, but the largest number are sub-lethally injured. As the irradiation progresses, more cells are killed, but their number is still insignificant until about 130 roentgens have been applied. Continuing the irradiation beyond this value increases the number of cells killed per unit of time; observable lethal effects on the cells of the skin are evident and increase as the irradiation is continued.

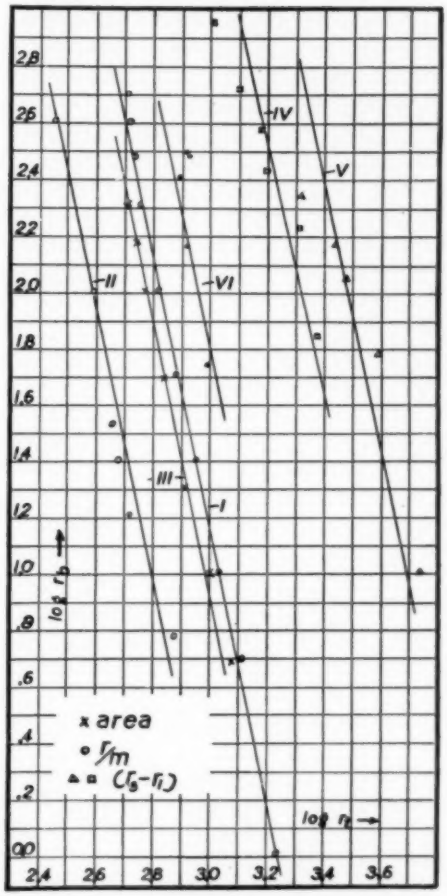


Fig. 5. Clinical data: intensities plotted against total r's required for equal visible reactions.

F. Clinical Doses: On the basis of equations 7 and 8, the effectiveness of radiation on deep-seated lesions is calculated as follows. For an erythema 600 roentgen-minutes of a well filtered radiation must generally be applied to the surface layers of the skin in a single application. Of these, 470 (*i. e.*, 600 − 130) are the biological portion causing the observed erythema. Assuming that a deep-seated

lesion receives 50 per cent of the intensity applied to the skin, and that the lesion is of a low degree of sensitivity, and requires 180 roentgens as a latent dose, then 120 (300 − 180) roentgens are biologically effective. Therefore, to produce the equivalent of a skin erythema dose in the lesion would require 470/120 or about 4 applications of 600 roentgens. Each of these must be directed upon the lesion from a different portal, and each must be applied on a different day.

The same four doses can, however, be given without time interval, or close together in one day. There will then be a loss of but one latent dose, because the three doses that follow the first are given without the time interval necessary for recovery. In the first case, the biological dose, according to equation 7, is $n(r_s - r_l) = 4(300 - 180) = 480$ roentgens. In the second case, according to equation 8 (where recovery of the latent dose between $n - l$ applications is absent), the biological dose is $nr_s - r_l = 1{,}200 - 180 = 1{,}020$ roentgens.

G. Conclusions:

1. With the beginning of irradiation of tissues, a sub-lethal cell injury develops from which the cells may recover; with continuing irradiation, the cell injury becomes lethal and terminates with cell deaths.

2. The recovery of normal skin cells from sub-lethal injury is substantially complete in about one day. Tissue or organ repair is slower than repair of sub-lethal cell injury and is brought about by cell proliferation causing regeneration, scarring, or fibrosis.

3. A substantial number of cell deaths occur after about 130 roentgen-minutes of well filtered 200-kv. radiation have been administered; this is the latent skin dose.

4. Visible skin changes are due to the biologically actinic portion r_b, *i.e.*, the single dose r_s minus the latent dose r_l.

5. Other biological effects of doses applied repeatedly at intervals, permitting full recovery from sub-lethal cell injury (over twelve hours), are roughly proportional to the sum of the single doses, each minus the latent dose.

6. Biological effects of doses applied repeatedly without time intervals are proportional to the sum of the single doses minus one latent dose.

7. After more than 8 irradiations of a tissue, there are an apparent fatigue for repair and an apparent decrease of the value $r_l = 130$ roentgen-minutes.

III. TISSUE INJURY AND RECOVERY EQUILIBRIUM

A. History: Many commendable attempts have been made to find a satisfactory function representing the recovery of living tissues from injury by radiation of various quantities and qualities. Of these some of the more important are briefly reviewed.

1. An interpretation of the changes produced in tissues by the absorption of roentgen rays was attempted by Kingery (22), who suggested the idea of a "mass reaction" to determine the rate at which the effects are lost. This would depend on the time, rate, or frequency with which exposures are repeated and the quantity that is administered at each exposure. Kingery concluded, however, that a rigid demonstration is impossible because of the inherent difficulties in estimating tissue effects.

2. Pfahler (23) originated the concept of a fixed percentage of daily repair which proved valuable in practical and clinical respects but was not based on any fundamental concept of recovery or repair. It was generally accepted that the recovery of tissues could not be a fixed percentage of the roentgens applied and independent of other factors. MacComb and Quimby (15) also concluded that "it makes very little difference into how many fractions the total dose is divided, so long as the total time remains the same." These conclusions are probably based on the assumption that a slow and continuous repair is taking place, according to which all cells and tissues recover completely if sufficient time is allowed. Both these concepts fail to consider the composite structure of

tissues and an adequate recovery rate of each cell type or component. These concepts were not consistently verified by experiment.

3. Quite a different point of view is held by Love (24), who considers that the cell during its life cycle passes through a stage in which it is particularly susceptible to the effects of radiation. He assumes that the resultant effects of irradiation depend on the doses received by the individual cell at the time when it is passing through the sensitive stage. Love finds by calculation that the biological effect of a predetermined dose in a given tissue is greatest for some specific value of radiation intensity. Strictly speaking, he fails to consider a recovery effect but he attributes the final biological effects to the relation of a sensitive period in the life of the cell and the intensity of the applied radiation.

4. The final effects of radiation are also estimated by Lea (25). He makes two definite assumptions about the manner in which the residual effect of a given radiation dose diminishes with time. One is that the recovery takes place in a definite time. The other is that the accumulation diminishes exponentially with time. The solution of both functions, as he derived them, results in curves which are not in good agreement numerically with experimental results.

B. The Problem: From the foregoing it is seen that Kingery stated the problem verbally and that Lea formulated a mathematical expression of it in a differential equation. This, however, is not a solution. Several solutions have been suggested, none of which is stated clearly or supported experimentally. Lea supposed that recovery from the effects of the action of the rays was completed after the fixed time, t. For a hypothesis involving one hit or only a small number of hits, this is a reasonable assumption. The observations, however, indicate that a large number of hits are required to produce the death of a cell and that a large dose of 130 roentgen-minutes is tolerated by the normal adult skin as a latent dose. These facts make the assumption of a fixed repair time no longer a reasonable one. Rather, it appears that the healing from radiation effects would progress exponentially with time. This was also found experimentally for the healing of wounds, the area of which was shown by du Noüy (26) to cicatrize in proportion to the size and the square root of the time.

In line with the results of a constant term, therefore, it is assumed that a diminution of the irradiation effect with lapse of time depends on the quantity or extent of the injury or damage D_t, the time t, and a fraction of recovery γ in the unit of time t. This factor indicates that the repair of a damaged cell does not take place in a fixed time but, according to the multiple-hit theory, the cells may be injured in various degrees, and thus will require various lengths of time for recovery. It is a statistical factor of proportionality, indicating the percentage of cells which in unit of time undergo repair. Further assumptions as to details of the process are not considered.

C. Solution: Expressing the problem in mathematical symbols, the dose accruing after a time t under the opposing effects of the radiation absorbed in unit volume of tissue ρ and the rate of recovery γ taking place in unit of time, is

$$D_t = \rho - f(D) \tag{9}$$

Solving the function $f(D)$ according to the above, by substituting γD for it, we obtain

$$\frac{dD}{dt} = \rho - \gamma D \tag{10}$$

By integration the above equation becomes

$$D_b = \rho/\gamma(1 - e^{-\gamma t}) \tag{11}$$

for the biologically actinic rate D_b. This is the fundamental equation governing the ratio between the rate of injury or damage caused by the radiation and the repair rate that follows.

It is, however, necessary at this time to direct attention to the fact that ρ, the rate

of injury, is not the measured radiation intensity r/m in roentgens, but is equal to the mass-roentgens $(m\text{-}r)$ stopped and utilized in 1 cm. of tissue (as is outlined in Section I); hence,

$$\rho = (m\text{-}r) = -I_x\mu = \mu I_0 e^{-\mu x} \qquad (12)$$

D. Construction of the Equilibrium Rate Curve: The factors arranged in equation 11 represent the biologically actinic radiation rate. If we put $\rho/\gamma = D_q$, the equation will be,

$$D_b = D_q - D_q e^{-\gamma t} \qquad (13)$$

D_q is the equilibrium biological actinity or action rate, which is attained only some time after the start. The value of the second part of equation 13, $D_q e^{-\gamma t}$, is to be subtracted from the first. The second term defines how the equilibrium dose rate D_q is built up from the beginning of the irradiation. Provided there is no radiation effect already present, the injury or damage is minimal at the start, increasing with the duration of the irradiation process until the equilibrium ratio D_q is reached.

It may be instructive to inspect Table II, which lists values of the expression $e^{-\gamma t}$ (for more extensive tables consult Smithsonian Physical Tables, Table 13).

TABLE II

γt	$e^{-\gamma t}$	γt	$e^{-\gamma t}$
0.0	1.00	1.0	0.37
0.05	0.95	1.25	0.29
0.10	0.90	1.50	0.22
0.20	0.82	1.75	0.17
0.30	0.74	2.00	0.13
0.40	0.67	2.50	0.08
0.50	0.61	3.00	0.05
0.75	0.47	4.00	0.02

For a short exposure time the product γt is small and the value of $e^{-\gamma t}$ approaches unity; as a result, the nearly full value of D_q subtracted from itself leaves only a small value for the equilibrium action rate. Gradually, with increasing time of irradiation, the value of γt increases and the maximum equilibrium value of the action rate D_q is approached. No further increase in the action rate occurs, and the ratio of the rates of injury and of recovery remain constant.

In summary, the factors of this equation represent the opposing effects of injury from a radiation quantity reaching the lesion and of recovery activity of the cells; this is the result of normal physiological function of the living cell. In these formulae the lethal cell effect is not considered; the direct discussion of equation 13 is limited to a consideration of a reversible and sub-lethal response of cells to injury from irradiation.

As long as the injury to cells is sublethal, the rates of injury or damage, ρ, and of repair or recovery, γ, at any time during the irradiation, are substantially equal. The recovery generally lags in time behind the onset of the radiation injury. This lag may amount to what usually is called the "latent dose." From the moment that the irradiation ceases the process of recovery of cells continues until all sublethally injured cells are restored to normal.

If any cells are lethally injured, the dead cells constitute tissue damage which, after the sub-lethally damaged cells have recovered, undergoes tissue repair, a much slower process;[3] the radiation causing this damage might be called a "tissue dose."[4]

E. Construction of Equilibrium Rate and Percentage Killing Curves. (*a*) *For a relatively high radiation intensity, as when* $r/m = 60$*:* Based on these preliminary considerations, three equilibrium rate curves are constructed, each for a different radiation intensity. But the absorption coefficient of the radiation $\mu = 0.13$ and the recovery factor for skin tissues $\gamma = 0.22$ are kept constant.

[3] From the clinical point of view the repair of tissues must also be regarded as a reversible process. A tissue repair may be observed after the second or third week. This is usually outside the treatment period and is not taken into consideration in this discussion. But in many instances the repair of tissues may alter the appearance of the immediate reaction, especially if the treatments extend over a period of several weeks.

[4] A "dose" is the quantity of an agent which produces a definite observable effect, whence the terms erythema dose, lethal dose, inhibition dose, etc. The term dose should be applied only to a radiation quantity which produces or may produce a definite visible biological effect. Any radiation quantity which is not correctly proportional to visible biological effects is not a dose but merely a physical quantity.

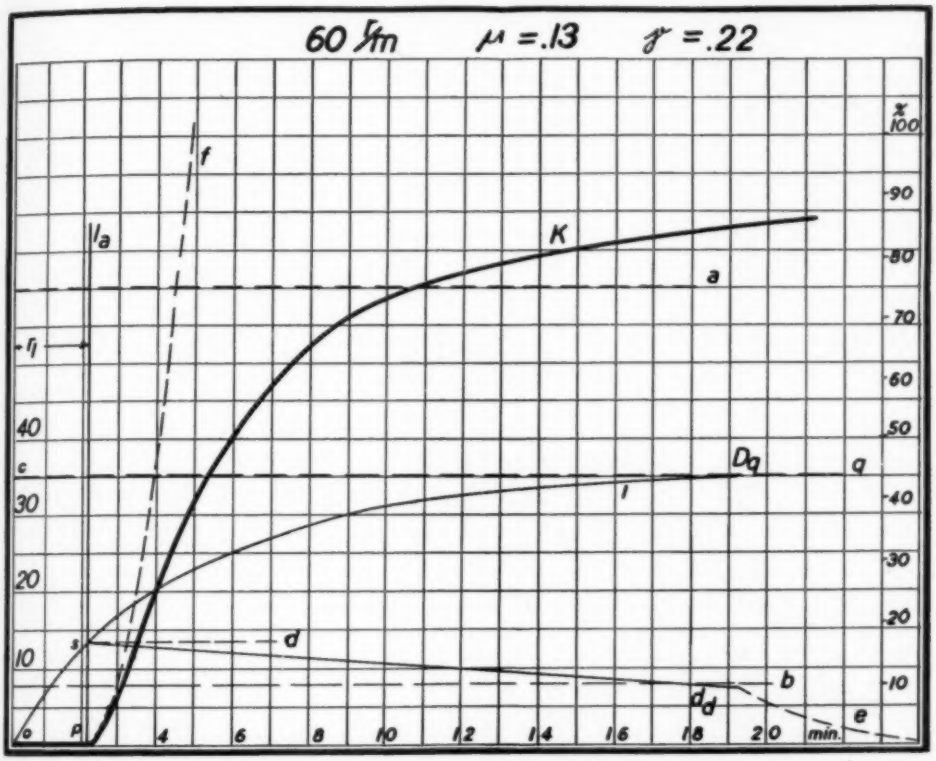


Fig. 6. Equilibrium rate, biological action rate, and percentage cell-killing curve for high radiation intensity.

In Figure 6, the radiation intensity applied and measured as 60 r/m is shown as the straight line a; the mass-roentgens, *i.e.*, $60 \times 0.13 = 7.8$, is shown as line b, and the irradiation time in minutes is plotted along the abscissa. Equation 13 is represented as the curve o–l–q; the horizontal portion q is the equilibrium rate D_q when $D_q e^{-\gamma t}$, after the lapse of sufficient time, has become negligibly small; the portion o–l is the ascending part determined by the second portion of equation 13 and it starts with the irradiation; the curve e is the theoretical recovery rate $De^{130/(r/m)}$ of the sub-lethally injured cells after irradiation has stopped.

The portion represented by the area o–c–l above the curve o–l–q evidently is radiation completely lost by recovery during the application of the rays. The concept of a tissue dose, however, implies that the sub-lethally injured cells are lethally damaged only on receiving an additional radiation quantity. Therefore, two portions, the area o–c–l, which represents recovery during irradiation, and a certain portion under the bent curve, which represents sub-lethal and recoverable cell damage, are completely lost in so far as tissue effect is concerned, provided the necessary recovery time is permitted. The value of these two portions as determined from experimental data relating to well filtered radiation acting on normal adult human skin cells (Section II) is 130 roentgen-minutes.

The vertical line l_a at the point 130/60 minutes is the exposure time for the latent dose r_l. At its intersection with the equilibrium rate curve, the line d is drawn parallel with the abscissa. Since killed cells do not recover, the latent dose decreases as the necrotic dose (100 per cent cell killing effect) is approached. The

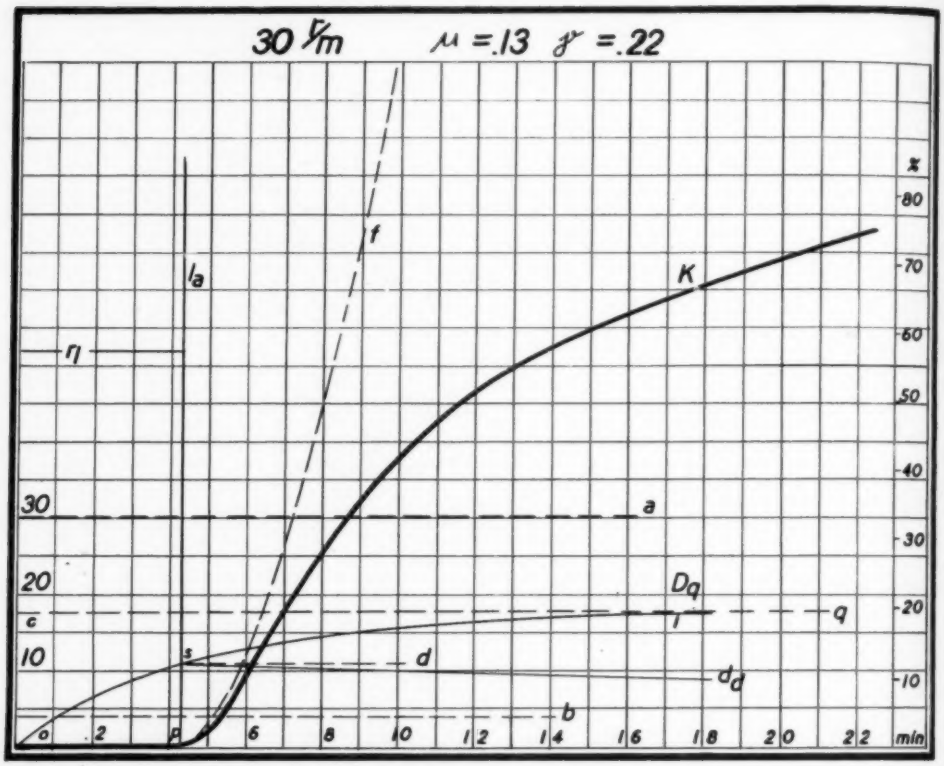


Fig. 7. Equilibrium rate, biological action rate, and percentage cell-killing curve for medium radiation intensity.

distance between the line d_d and the time axis represents reparable cell damage, from which the cells recover. The area above this line, bounded by the equilibrium rate curve, represents the irreversible or lethal damage to cells; this represents destructive changes of tissues or tissue action.

To calculate the biologically effective dose from the exposure time, *i.e.*, from the end of the latent dose $130/60 = r_i$ to the end of the treatment, the tissue rates are summed up by adding the vertical components for uniform increments of time. The result is the rapidly rising curve f, which is designated the biological action curve. Each vertical value under this curve represents the instantaneous value of the tissue action piled up at the given moment.

The curve f is based on the assumption that an unlimited number of cells liable to be killed are available and that the number of cells which are already killed at any given moment is negligibly small in comparison with those still alive. This condition obviously does not exist in tissues; when a necrotic dose is approached, nearly all the cells are killed and this condition is reversed.

While the point 130/60 is the starting point for the killing curve, an end-point is still required representing 100 per cent killing of cells. This is the necrotic dose which, based on clinical experience, is arbitrarily made equal to 6 erythema reaction quantities or to $6 \times 550 = 3{,}300$ roentgen-minutes of well filtered radiation. Because the full necrotic value of the curve would theoretically extend to an infinite exposure time, a slightly lower and more definite point is selected; 95 per cent of the necrotic value is taken to calculate the

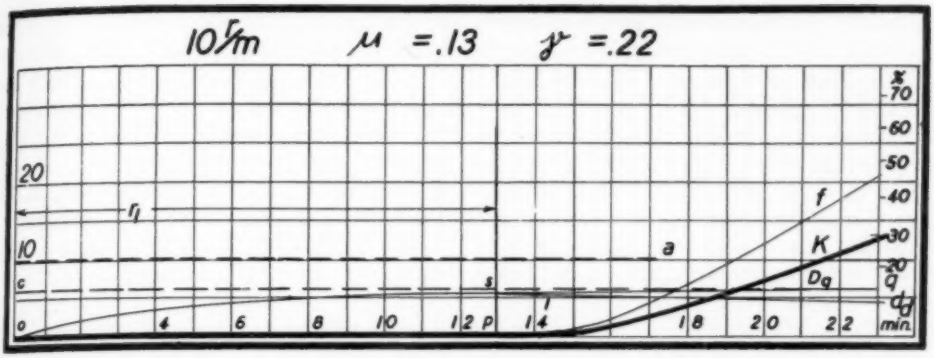


Fig. 8. Equilibrium rate, biological action rate, and percentage cell-killing curve for low radiation intensity.

minutes of exposure required to kill 95 out of every 100 cells, and this point is then taken as the end-point of the biological dose.

For example, at the point where 50 per cent of the cells have been killed, only one-half of the original number of cells are left intact. With only one-half of the original number of cells present, the probability of hitting live cells with photons is decreased to one-half, and twice the exposure time is required to cause the appropriate number of cell killings intended at the start. Thus $100/(100 - x)$ represents the actual exposure time for each point along the biological action curve where x is the expected percentage of cells actually killed. For the 95 per cent killing-point we would have as the total exposure time $(100 - 95)/100 = 1/20$ of the exposure time producing total necrosis, or of $3300/60 = 55$ minutes. By adding to this time 2.16 minutes for the latent dose, the exposure time is derived for 95 per cent of the cells to be killed; it is equal to 4.9 minutes. The intersection of a vertical line at this point with the biological action curve, f, gives the necrotic dose-point on the supposition that an infinite number of cells are present; according to conditions existing in tissues, this point is the maximum of the actual killing curve at the actual exposure time 3,300/60 or 55 minutes. If other points are similarly determined, we obtain the percentage killing curve K. The vertical distance to the abscissa, divided into 100 equal parts, represents the percentage of cells killed or still alive.

The curve so obtained is sigmoid-shaped but not symmetrical or S-shaped; it is asymmetric, a skew-curve, with a short and sharper bend at its lower end and a rather long and flatter bend at its upper portion. The percentage killing curves derived as above described are similar to those reported for Drosophila eggs (27), axolotl eggs (28), algae (29), yeast cells (30), sunflower seeds (30), bean sprouts (31), etc. Many authors assume the percentage killing curves to be S-shaped, and several attempts have been made to derive similar curves from probability data (32), but these curves are in less good agreement with experimental biological data.

(*b*) *For a relatively moderate radiation intensity rate, as when* $r/m = 30$: Except for substituting $30 \times 0.13 = 3.9$ mass-roentgens, Figure 7 is developed similarly to Figure 6. The results are similar except that the values for the rate of irreversible tissue action are smaller for equal exposure times and that the latent dose is also longer. The percentage killing curve is flatter and its corresponding percentages of cell killing are obtained with proportionally longer exposure time.

(*c*) *For a relatively small radiation intensity rate, as when* $r/m = 10$: If $10 \times 0.13 = 1.3$ is substituted for the mass-roentgens, then the flat equilibrium rate curve, shown in Figure 8, is obtained. The latent dose r_l requires a rather long exposure time,

i.e., 130/10 = 13 minutes, and it is found that the equilibrium rate curve has already reached its maximum value, in about 16 to 18 minutes. This leaves a very small value for an irreversible tissue action rate, showing that if the radiation intensity is very small, due to a very low r/m output of the apparatus or to absorption of the rays in superposed layers, then a correspondingly smaller mass-roentgen rate results; with a but slightly smaller intensity rate (about 8 r/m with the same factors) there would be no tissue reaction obtainable. Moreover, owing to the very long exposure times, there may be a limited degree of tissue repair, which also tends to lessen the biological effects. There is either no visible biological effect on tissues or only a negligibly small one. Generally, the effects produced are different in character from the effects produced with the higher radiation intensities (33).

F. Conclusions:

1. Equation 13 represents a continuous action which does not account for any abrupt changes in the medium resulting from the irradiation. Irradiation of biological tissues results in a discontinuity when the cells are injured to such an extent that a small additional irradiation will cause a substantial number of cells to die.

2. Since the recovery rate is fixed for a given tissue as a natural property, the most outstanding feature shown by the three percentage killing curves is that the extent of the biological actinity of the radiation depends on the intensity rate and the absorption rate of the radiation reaching the lesion or on the mass-roentgens.

3. The rate of accumulation of biological tissue effect decreases and approaches zero as a critical lower value of mass-roentgens reaching the lesion is approached. It follows that a critical minimum amount of radiation absorption or mass-roentgens in a lesion is required for definite therapeutic radiation effects.

4. The shape of the percentage killing curve is not influenced by the wavelength or the intensity, but by the mass-roentgens reaching the lesion and the recovery factor of the tissue. With a large rate of mass-roentgens reaching the lesion, the lower end of the percentage killing curve is bent less sharply than with the smaller mass-roentgen rate. The upper bend is not changed, since it is due to the decrease of the number of live cells to be affected by the radiation as the necrotic dose is approached.

5. When a latent dose time $t_l = 130/(r/m)$ approaches the time required for reaching the full equilibrium rate, D_q (or when $e^{-\gamma t}$ has a value of about 3 or 4), indicating that the equilibrium rate has reached about 98 per cent of this full value, *i.e.*, when

$$D_q e^{-\gamma 130/(r/m)} = D_q, \tag{14}$$

the tissue action becomes negligibly small. Thus, for normal adult skin, if the latent dose application exceeds 14 to 16 minutes, *i.e.*, is less than around 8 r/m, and the absorption coefficient in the tissue is 0.13, the definite skin erythema changes or proportional changes in deeper located tissues are not obtained except after causing biological fatigue.

6. Conversely, if

$$D_q e^{-\gamma 130/(r/m)} < D_q, \tag{15}$$

then the applied intensity of the radiation and its absorption are sufficient to produce tissue action, and the difference between the above two terms is a measure of this. Thus the biological action produced is estimated by summation of all instantaneous ordinate values between the line representing the sub-lethal cell damage rate and the equilibrium rate curve from the time $130/(r/m)$ on to the end of the exposure.

IV. BIOLOGICAL ACTION AND CELL-KILLING CURVES FOR VARIOUS TISSUES

Differences in the degrees of sensitivity to radiation of the various organs and pathological changes form the basis of some methods of clinical application of highly penetrating radiation. It is known that any lesion having a higher degree of sensitivity to radiation than the adjacent and superposed tissues is comparatively easily influenced. A lesion having a lower degree

of sensitivity than that of the surrounding tissues cannot be easily influenced by externally applied radiation.

It is known that a relation exists between the reproductive function and the degree of sensitivity to radiation of the various organs and lesions. The apparent similarity between reproductive and repair functions makes a correlation between repair and sensitivity highly probable. For these reasons, and to establish one tissue as a reference point, the knowledge of the numerical value of the recovery factor for a well defined tissue is desirable.

A. The Numerical Value of the Recovery Factor for Normal Adult Skin: Human skin is selected for evaluation of the recovery factor, because the clinical changes in the skin are reasonably familiar. The experimental and clinical data of Holthusen and of Meyer (14) on the influence of r/m variation on the total roentgens required for equal erythema reactions are helpful. The former data include the use of gamma rays from radium for low intensities. It might be argued that in comparison with x-rays gamma rays have vastly different penetrative properties or intensity rates; yet, because of the scarcity of the elements which produce gamma rays, the source is generally small and as the result of this it is placed a short distance from the skin. In this relation the intensity distribution in the tissues is practically the same as that of x-rays employed from greater distances and with greater intensities.

A determination of γ from the Holthusen and the Meyer data may be accomplished by equation 13. Since the results observed are fully developed skin reactions which, when read, are at equilibrium, they obviously have the same recovery factor, and the second term of equation 13 becomes a constant. It follows that $D_b = \rho/\gamma + c$, and if we make $\rho = \log (r/m)$ and $D_b = -\log r_t$, we obtain

$$\gamma = \log (r/m)/ -\log r_t \qquad (16)$$

We have already plotted (Fig. 5) the data of Holthusen and Meyer in which the radiation intensity or the exposed area is varied. Changes in radiation intensities are related to changes of the exposed area. The ratio between definite biological doses and a variation of intensity gives a straight line whose slope is 0.22.[5]

Thus, the recovery factor or time rate factor for adult human skin is equal to

$$\gamma = 0.22 \qquad (17)$$

B. The Latent Dose: The same physical process is involved in causing injury to cells by radiation approaching the lethal point as that which follows and causes the cells to die. This implies that the recovery function of cells is the cause of two types of latent effect. A latent or lost radiation quantity is represented by the area *o–l–c* of Figures 6, 7, and 8 above the ascending equilibrium rate curve, which produces no injury to cells. A second latent portion is represented by the area *o–p–s* under the ascending equilibrium rate curve, which causes the building up of sub-lethal cell injury and which might be termed the actual latent dose. Therefore, the assumption might be justified that the two portions of the applied radiation quantity which comprises the latent dose are definite fractions of the radiation quantity which causes a definite biological change such as a skin erythema, and that a cell maintains a constant recovery rate or recovery factor γ.

The areas representing the actual latent dose for various radiation intensities, *i.e.*, 60, 40, 30, and 20 r/m, vary in size; for the highest intensity the area is smallest and for the lowest intensity it is largest. If, however, a correction is made for the effectiveness of each intensity by using mass-roentgens, then the values of the absorbed equilibrium ratios become equal for all of the four radiation intensity rates.[6]

[5] The slope of the data as plotted in Figure 5 is $m_{r_t} = 4.7$. Since D_b and r_t vary inversely, the slope for $m_{D_b} = -1/4.7 = -0.22$.

[6] The ordinate values represented under the curve are rates of a reversible reaction. A reversal of the process by recovery can, however, take place only while the effects are sub-lethal or latent, *i.e.*, below the line d or d_d; above this line and under the equilibrium rate curve, the effects are lethal and irreversible. Hence the area under the equilibrium rate curve from $t = 0$ to $t = 130/(r/m)$ represents the latent dose.

TABLE III

		Latent Dose				Erythema Dose		
r/m	$(m\text{-}r)$	$130/(r/m)$	Middle Height	Area	(Area × $m\text{-}r$)	$t/(r/m)$	Middle Height	Area
20	2.6	6.5	6.1	40	101	27.5	5.5	152
30	3.9	4.35	6.4	28	110	18.3	8.5	155
40	5.2	3.25	6.45	21.6	109	13.7	11.5	151
60	7.8	2.17	6.5	14	110	9.2	16.5	152
				Av. 26	Av. 107			Av. 152

The average values of the mass-roentgens which cause the latent dose for the four radiation intensities indicated above are taken from actual equilibrium rate curves. Figures 6 and 7 are the curves for 60 and 30 r/m, respectively.

It is apparent from Table III that the area for the actual latent dose multiplied by the mass-roentgens gives a constant value. This is required owing to the different extent of recovery during the administration of the latent doses when each requires a different exposure time. The erythema-producing dose, being irreversible, gives for each of the various intensity rates the same value. This is to be expected, since killed and destroyed cells do not recover but simply add up without any cell recovery.

Thus the ratio of the mass-roentgens of the latent skin dose to the skin erythema dose is roughly as 26:152 or as 1:6, *i.e.*,

$$\text{Latent dose} = (\text{erythema dose})/6 = (D_q \times t)/6 \quad (18)$$

From these considerations it appears that the latent biological dose should have a constant fractional value of the dose for visible biological change, such as the skin erythema.

Since a constant ratio between a latent dose and an established dose for a tissue effect exists, the question arises as to the magnitude of the latent dose for tissues which have a recovery factor different from that of the skin. Evidently this factor may be larger or smaller than that for the skin. Two typical cases will now be considered.

Assuming that $\gamma = 0$, there is then no ascending portion in the biological action curve and the equilibrium rate ρ/γ is infinitely large. All the radiation effects are additive and irreversible because there is no recovery in this case. Therefore, these conditions correspond to the action of radiation on lifeless and non-recovering material, such as chemicals, dyes, etc.

A living tissue having a $\gamma \neq 0$ recovery factor generally has some value $\gamma > 0$, *i.e.*, some value which characterizes it as a living substance. There is also a finite equilibrium rate which requires a latent period. Of the highly sensitive sex organs and the products of the sex organs, it is experimentally proved that radiation effects upon these are essentially irreversible and thus the radiation effects are additive, with no observable repair (34).[7]

Another kind of tissue may have a large recovery factor, indicating that the injured cells undergo repair at a high rate. The immediate conclusion follows that the recovery action rate is rapid and that the equilibrium rate is finally attained in a longer time than that required for the skin.

The arrangement of the injury term and the recovery terms in equation 13 suggests that if the recovery factor is large, as it is in the case of a tissue of low sensitivity, then an effective action should be obtainable by increasing the radiation intensity rate in proportion to the larger recovery factor. The sensitivity to radiation of all tissues can, therefore, be adjusted to equality if it is possible to adjust the mass-roent-

[7] If the radiation quantity known as the safety tolerance dose (35), which is 0.01 of an erythema dose per month, is a safe dose for the skin, it must be clearly understood that this radiation quantity is not necessarily also a safe dose for other tissues. For the sex organs the recovery is minimal and the radiation quantities received each month may be added without making any allowance for recovery. For the highly sensitive organs the recovery and equilibrium ratios are functionally related to these properties of the skin as their respective recovery coefficients.

gen rate in proportion to the recovery factors. The practical inference is that if the repair or recovery rate of a certain tissue is small, only a low radiation intensity rate is required to cause a certain desired tissue effect. For another tissue which has a higher recovery rate, a proportionally increased radiation intensity rate will accomplish the same result. A tissue which is recovering slowly (and which generally grows slowly) can therefore be successfully influenced with a small radiation rate (mass-roentgens), but a tissue which is rapidly recovering requires a proportionally higher rate of intensity or absorption for a similar result. Moreover, if the radiation intensity and absorption rates fall below a critical level, no effect or a different effect is obtained on tissue with a given mass-roentgen rate.

A conclusion from these interpretations of equation 13 is that the Draper-Grotthus law (that only the absorbed radiation is actinic) is applicable strictly to non-living substances which do not recover. For living tissues this law requires an addition of a time rate of recovery for the tissue considered. A measure of the biological action, or the rate of equilibrium action, is therefore obtained by dividing mass-roentgens by the recovery factor. Furthermore, the latent dose which is ineffective in producing permanent tissue changes must be subtracted from each single application of the radiation; the question of recovery and repair between single irradiations must be accounted for in order to determine the biological dose resulting from the radiation.

C. Repeated Applications: With regard to repeated doses of radiation, integration of equation 10 between appropriate limits discloses the final result. Integrating it between the limits D_o and D_t, where $D_o > 0$, or when a dose effect is still present from a previous application and a new dose is added, it follows that,

$$D_b = D_o e^{-\gamma t} + D_q(1 - e^{-\gamma t}) \qquad (19)$$

$$= D_q + (D_o - D_q)e^{-\gamma t} \qquad (20)$$

This equation shows that the sub-lethal cell injury adjusts itself to approach the equilibrium dose rate D_q. Residual and newly applied lethal or tissue doses, however, have zero recovery. They undergo no adjustment and are fully additive. But if tissue repair has set in, then the additive effect will no longer be linear.

D. Biological Action and Cell-Killing Curve for Various Tissues: In the preceding section lethal cell curves for various mass-roentgen rates were constructed as they were obtained from variation of the radiation intensity or the depth location of the irradiated tissues. In each instance, the reacting tissue was assumed to be the skin and its recovery factor $\gamma = 0.22$ was kept constant.

It is now assumed that various different tissues, each having a different recovery rate, are exposed to radiation and the mass-roentgens reaching the reacting tissue are constant. Such conditions prevail when various tissues or tissues with pathological changes are irradiated. Therefore, μ and ρ are kept constant and γ is made the variable.

(*a*) A tissue of greater sensitivity to radiation than the skin has a recovery factor which is smaller than the recovery factor for the skin, *i.e.*, $\gamma < 0.22$. Since the physical utilization of the absorbed energy is the same in all cells having similar elemental compositions, it is assumed that a tissue more sensitive than the skin is composed of cells which recover at a slower rate than those of the skin. Assuming the recovery factor 0.11, we can again construct the action rate curve f_1 and the cell-killing curve K_1 of Fig. 9. To compare the reaction of the rays on skin with more highly as well as less sensitive tissues, similar curves, with $\gamma = 0.22$ for skin, $\gamma = 0.11$ for slowly, and $\gamma = 0.44$ for rapidly recovering tissues, are all drawn on Figure 9.

Since the ratio between latent and erythema doses is constant (see below) it follows that the latent dose for a more sensitive tissue must be proportionally less than that for the skin. As expressed in equation 13, the equilibrium dose rate for skin is $(20 \times 0.13)/0.22$ for 20 *r/m*. Then

for the more sensitive tissues it would be $(20 \times 0.13)/0.11$ and for the less sensitive tissues, it would be $(20 \times 0.13)/0.44$. The latent dose must be in inverse ratio to these values or in direct ratio to the recovery factor, *i.e.*, as 0.22:0.11; or as 2:1. Thus the equilibrium rate curve for the more sensitive tissue will arrive at a maximum value at a later time than the curve for the skin. Both the development of the maximum equilibrium action rate and recovery after irradiation ceases consume a shorter time for the more sensitive tissue than for the skin.

Moreover, for equal radiation quantities, the percentage of cells killed in the more sensitive tissue is distinctly larger than in the skin; the proportion, however, is not constant but depends on the irradiation time.

If the normal skin is not to be damaged by irradiation beyond a stated extent, then the therapeutic treatment of a lesion which has a smaller rate of recovery than the skin, *i.e.*, if the recovery factor $\gamma < 0.22$, can be effected by one of two possible methods.

(1) By applying continuously a single radiation quantity in which the mass-roentgen rate is such as not to accumulate a tissue dose on the skin, *i.e.*, where $D_q = D_q e^{-0.22 \times 130/(r/m)}$. If the same or only slightly smaller mass-roentgens reach the lesion which is recovering less rapidly than the skin, owing to the smaller recovery coefficient, a tissue dose will accrue in the lesion, while in the skin, having a larger recovery factor, a tissue reaction is avoided. Thus a tissue dose of any desired magnitude can be summed up in the lesion while all action on the skin is sub-lethal and reversible.[8]

Irradiation given in divided doses would, however, diminish the tissue effect on the lesion, and when more than a few interruptions were made would result in failure.

(2) By applying divided quantities of radiation at such intensity rate and absorption coefficient that the mass-roentgens for the skin for the time of each irradiation multiplied by the number of interruptions does not exceed a permissible erythema effect (see equations 7 and 8).

The effect on the lesion can be still further multiplied without exceeding a permissible skin reaction by cross-firing over several skin areas while directing the beam always upon the lesion. But the time interval between the cross-firing cycles or single applications should for greater effectiveness on the lesion not be more than the recovery time for the sub-lethal skin damage. Then, on account of the longer recovery time required for the slower recovering tissues, there will be still left not only the entire tissue dose, but also some of the sub-lethal and reparable cell damage. A new application will then add to this residual reparable damage before it has had time to be fully repaired. Thus a tissue damage is reached with but a small additional amount of radiation.[9]

(*b*) For tissues which recover at the same rate as the skin, $\gamma = 0.22$, the cell-killing curve K_2 of Fig. 9 is obtained. There is evidently no opportunity to take advantage of any specific method of variation either of the intensity rate or division and time spacing between applications. All devices to obtain large tissue doses must be based on geometrical principles of dose distribution and on the cross-firing principle.

(*c*) For tissues which recover from injury at a high rate, *i.e.*, $\gamma > 0.22$, the value of $\gamma = 0.44$ is assumed and the equilibrium action rate curve f_3 and the cell-killing curve K_3 are obtained. We find that the equilibrium rate has almost completely reached its maximum value $(130 \times 2)/30$

[8] K. Englmann (36) reported that with a low intensity rate (5.4 *r/m*) the bone marrow can be permanently destroyed without any danger of injury to the skin or the connective tissues. At a higher intensity rate of 30–50 *r/m*, the same result on the bone marrow causes severe and permanent injury to the skin.

[9] The simultaneous application of several radiation beams at one time might appear as an ideal method of increasing the mass-roentgen rate upon the lesion and distributing the mass-roentgens acting upon the skin over several areas. However, consecutive cross-fire applications entail only a small time factor during which there could be recovery; the value of the simultaneous application of several beams amounts to this saving of loss by recovery but in addition there is a much greater mass-roentgen rate applied to the lesion and the rate of equilibrium action is considerably increased.

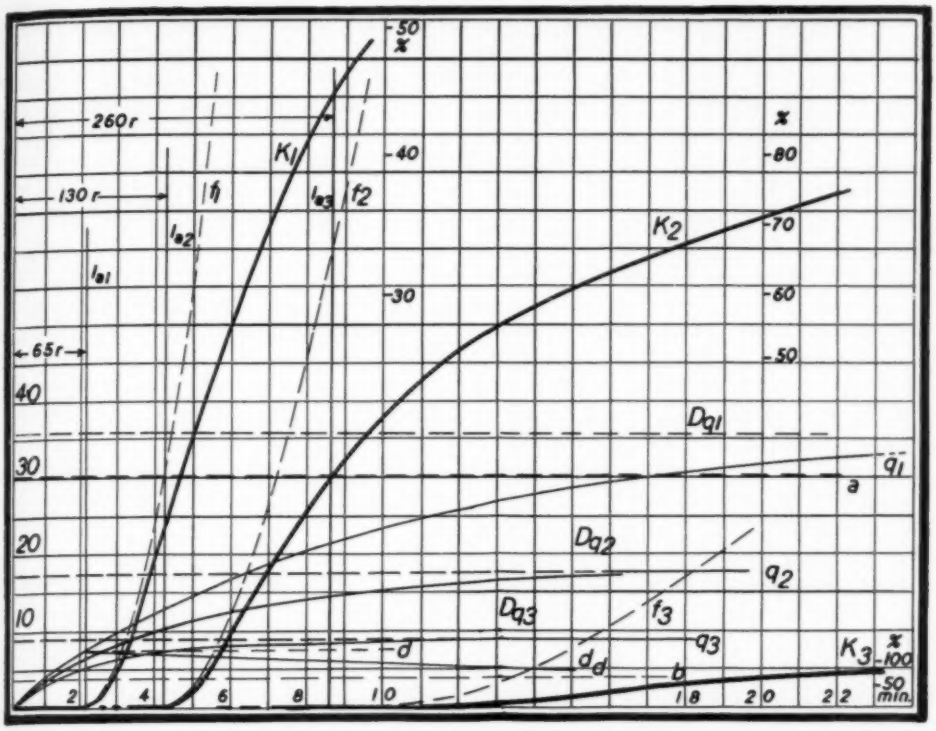


Fig. 9. Equilibrium rate, biological action rate, and percentage cell-killing curves for 3 tissues having different radiation sensitivities.

= 8.7 minutes during the latent dose time. The difference between the curve and the line d_d, which is now nearly parallel with the time axis, under these conditions gives rise to the action-rate curve f_3 and the cell-killing curve K_3.

The relatively very large difference is striking in biological response to a recovery factor equal to one-half or double the recovery factor of the skin. While the dose effect of a given radiation quantity for the slower recovering cells is distinctly greater than for skin, it is shown that for the rapidly recovering cells ($\gamma = 0.44$) the dose effect is considerably smaller in proportion. Irradiation of such lesions with small mass-roentgen rates would cause failure in an effort to effect a therapeutic result.[10]

In practical respects a distinct gain in therapeutic results seems to be obtainable through methods by which the recovery coefficient and the sensitivity of a tissue to be treated can be influenced to result in a greater therapeutic action ratio. This would be by making the recovery function smaller or by increasing the mass-roentgens whereby the increased action ratio is obtained.

For the successful treatment of rapidly recovering tissues which are imbedded in less rapidly recovering tissues, not much can be suggested to avoid over-damage to the latter, at the same time delivering an effective therapeutic action upon the for-

[10] Experimental determinations of Crowther (37) with *Colpidium colpoda*, which has a very high recovery rate, show clearly the effects of recovery during and following irradiation. For any cell-lethal effect these organisms require a single quantity of at least 76,500 roentgens given at a rate of 4,000 roentgens per minute; at a rate of 200 roentgens per minute no lethal effects could be produced.

With three interruptions of two hours each, a total of 114,750 roentgens at a rate of 4,000 roentgens per minute is required for the same proportional number of deaths; but with three hours between the same applications as before, no deaths were caused even though four applications were given in one day and repeated on the same specimen on the following day.

mer. Variation of the action rate (mass-roentgens) or of dose division holds out no direct hope. Only direct delivery of the radiation to the lesion or willful injury to the adjacent or superposed tissues insures the necessary high mass-roentgen rate to the lesion for satisfactory clinical improvement. Divided doses seem, under the circumstances, to be ineffective, since the latent dose for the rapidly recovering tissues is longer and the effective biological action is much smaller than for the skin. The conditions are essentially those described as suitable for the treatment of slowly recovering tissues but not for those recovering faster than the skin.

E. Discussion: Through observations on tissues which react differently in quantitative respects to irradiation, the well known Bergonié-Tribondau (38) law was derived. It claims that the biological action of rays is greatest with cells having the greatest reproductive function, with the longest karyokinetic period, and the least differentiated morphologically and functionally. From this law it is recognized that growth and functional activity of cells may be inversely related to their radiation sensitivity.

Functional activity and growth may not, however, be directly related in the same manner as growth and degree of organization. The recovery factor appears merely to be a measure of the sum total of the functions which control cell recovery from radiation injury. It is not possible to define how the other properties of cells, *viz.*, growth, karyokinetic action, and function, are correlated.

Theoretically, the recovery of sub-lethally injured cells should take place at a rate equal to $D_e e^{\gamma t}$; the curve representing the recovery would be of the same general shape as that for the building up of the equilibrium rate, except that it is bent in the opposite direction. There is, however, good reason to believe that the recovery is considerably slower and it may be preceded by a latent period. The experience with the healing of wounds indicates that there might be a delay in the recovery action and that the exponential values of the theoretical requirements might not agree with the actual rate at which healing takes place. Local conditions and variations are factors which cause this deviation from theoretically expected healing rates.

The data of Reisner (11) indicate that the sub-lethal damage of skin tissue cells should be complete in about twelve hours. This relates to the recovery of irradiated cell injury. The repair of lethally injured cells is slow. The data of Duffy, Arneson, and Voke (39) on regeneration of human skin appear to confirm this. They note a further repair of tissue besides the complete recovery of sub-lethally injured tissues for twenty-four to forty-eight hours after irradiation with a therapeutic dose.

F. Conclusions:

1. Cell-killing curves differ slightly in shape and are generally skew-shaped; the slope of the curves is related to variation in the mass-roentgens reaching the cells and to the rate of cell recovery.

2. Below a critical rate of mass-roentgens a tissue reaction may fail; the effectiveness of the radiation increases with the increase in mass-roentgens and decrease in recovery rate.

3. The same degree of biological activity will be produced when the radiation intensity and the absorption factor are so adjusted that the ratio of mass-roentgens to the recovery coefficient of each tissue is equal.

4. Various fractions of radiation quantities summed up to the same total not only fail to produce the same biological changes but they also produce different qualitative changes.

5. The recovery factor γ is a statistical factor which indicates the rapidity of recovery of skin or other tissues if injured sub-lethally by radiation. It includes secondary factors controlling recovery, as nutrition, insulation, etc., which are affected by extrinsic factors influencing the healing of vascular skin tissues. Its relations with other biological cell functions are not implied.

6. Conditions are outlined under which slowly recovering tissues can be effectively treated clinically.

7. A negative outlook for the clinical treatment of deep-seated rapidly recovering tissues is pointed out and possible improvements are suggested.

8. The value of the recovery factor for healthy adult human skin is derived from the known increments of radiation quantities required for equal biological results in various irradiation times.

Thankful recognition is due Dr. Wm. H. Meyer, whose clinical experience and data are freely used as starting points for these derivations. Also the deductions have invariably been checked with his clinical observations.

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Comparative Isodose Charts for 200 Kv., 400 Kv., and 1,000 Kv. X-Rays[1]

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FROM A PHYSICAL point of view, the advantages of the higher voltages are twofold, namely, an increase in the percentage depth dose at the greater depths and a marked reduction in the amount of radiation scattered to the tissues immediately outside the primary beam. For voltages of the order of 200 kv. with large field sizes, the radiation scattered outside of the primary beam reaches a maximum, while with lower and higher voltages the lateral scattering is less. In fact, as pointed out below, with irradiation of a large field at 200 kv. the volume of tissue irradiated outside the beam may be as much as 50 per cent of the entire beam. This may be a serious handicap when considering the total amount of energy delivered to a patient. Another disadvantage of this large amount of scattering outside the beam at 200 kv. is discernible when using the multiple port technic. A close spacing of adjacent ports may result in the production of hot spots below the skin, causing damage to healthy tissue.

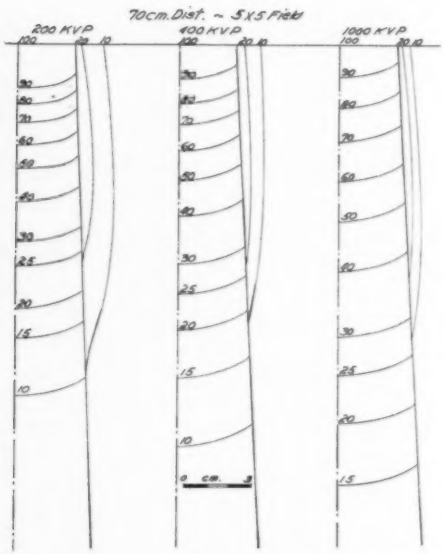
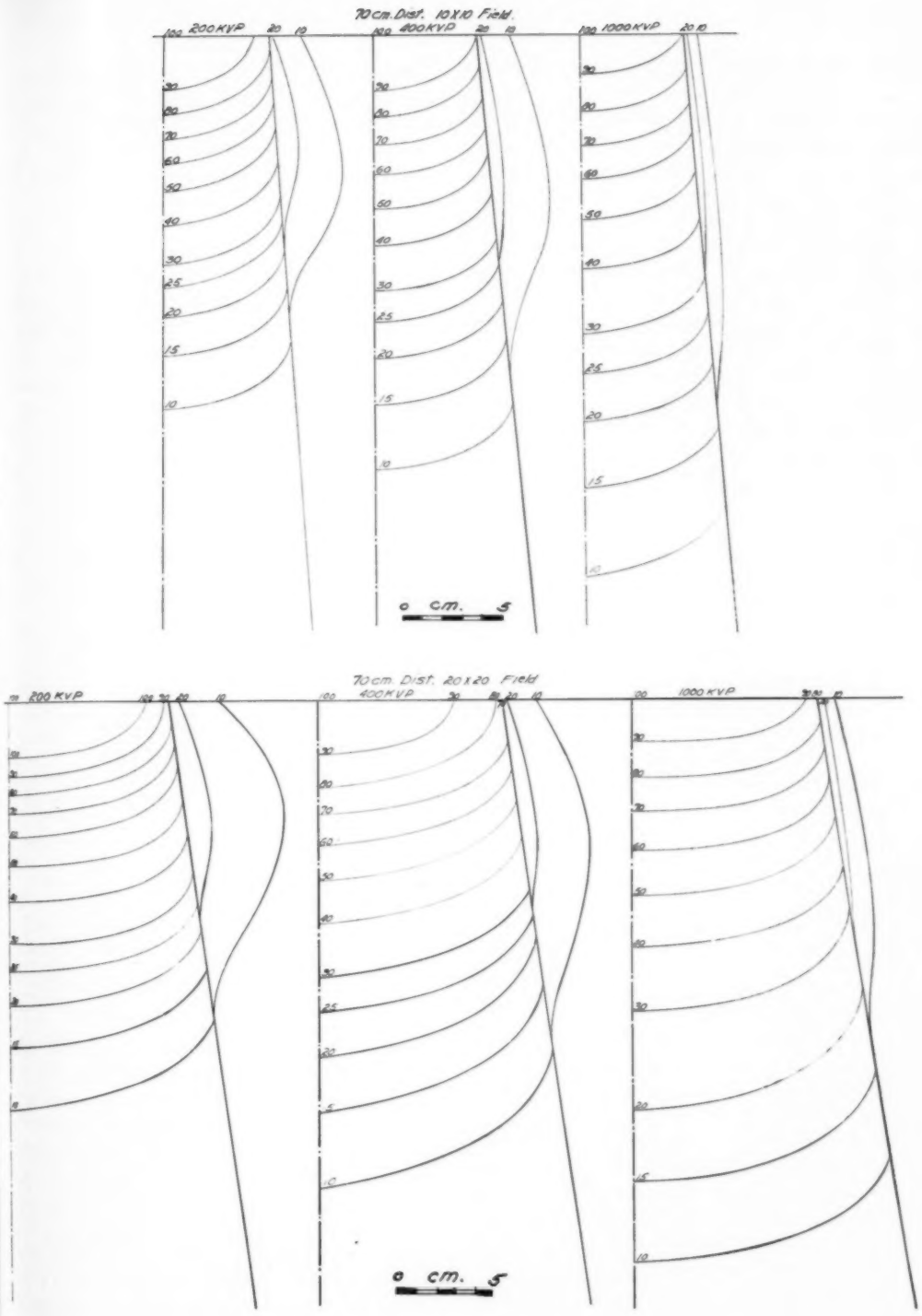


Fig. 1. Comparative isodose chart for 5 × 5-cm. field.

Although there have been many publications of isodose curves for 200 kv., it was felt that, for purposes of comparison, measurements at this voltage should be repeated under the same conditions and in the same manner as the measurements at 400 and 1,000 kv. Measurements were therefore made at the three voltages with a thimble type ionization chamber (Victoreen condenser r meter), used with typical field sizes—5 × 5, 10 × 10, and 20 × 20 cm.—at a distance of 70 cm. A prestwood phantom was used as the absorbing and scattering medium. By measuring the intensity of the central ray at the surface, at various points of depth, and also at numerous points lateral to the central ray at the same levels, it was possible to express graphically the change in intensity at any one depth when moving laterally from the central ray to the periphery of the beam. In this way data were obtained to make a complete isodose curve, as shown in Figures 1, 2, and 3. The actual spread of the beam was determined by exposing photographic films placed on the surface of the phantom and at a depth of 10 cm. The quality of the beam generated at 200 kv. was 155 X.U.; at 400 kv., 60 X.U.; and at 1,000 kv., 27 X.U. The 200 and 400-kv. beams were collimated by means of an aperture cut in 1/4-inch sheet lead which was suspended 7 cm. above the phantom. The 1,000-kv. beam was limited by an aperture in 1-inch lead, 30 cm. from the target, and a second aperture 4 3/4

[1] From the State Institute for the Study of Malignant Diseases, Buffalo, N. Y., Burton T. Simpson, M.D., Director. Accepted for publication in June 1941.



Figs. 2 and 3. Comparative isodose charts for fields 10 × 10 cm. and 20 × 20 cm.

cm. thick on the surface of the phantom.

In order to facilitate comparison of the isodose curves for the three field sizes and the three voltages, only half of the isodose curves are shown, arranged in groups of three for each field size. If we consider the volume of tissue irradiated outside the beam to the 10 per cent line with respect to the total volume within the beam to the 20 cm. depth, we can estimate the change in volume when going from 200 to 1,000 kv. At 200 kv. for the three fields the ratio of the two volumes is approximately 2 : 1; in other words, the volume of tissue irradiated outside the beam is 50 per cent, whereas with 400 kv. it amounts to approximately 35 per cent and with 1,000 kv. it is still further reduced, to approximately 20 per cent. These figures are representative for the conditions mentioned above and will vary depending on the degree of shielding and on the position and type of collimation used.

SUMMARY

Isodose charts are presented which show the increase in depth dose with increasing voltage and the decrease in radiation scattered outside of the primary beam with increasing voltage. A note is included indicating the relative volume of tissue irradiated outside of the beam for the various voltages and field sizes.

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Stepless Voltage Controls for X-Ray Generators[1]

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FOR MANY YEARS it has been customary to employ an autotransformer to supply the primary voltage for x-ray therapy and diagnostic high-voltage generators. This device consists of a transformer in which the primary and secondary coils are combined in a single coil. The

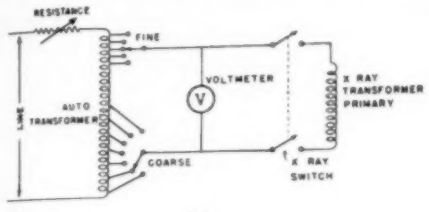

FIG. 1

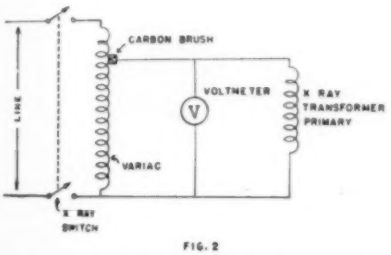

FIG. 2

Fig. 1. Old method: Operation of the x-ray tube must be suspended before any voltage change can be effected.

Fig. 2. New method: Any desired change in voltage is possible while the tube is in operation.

line voltage is connected between two fixed points on the coil; the secondary voltage is taken from taps at various points along the coil. In order to make small variations of this latter voltage possible, it is usually necessary to bring out a considerable number of taps to switches on the control board.

The usual method of procedure in adjusting the voltage on the x-ray tube is to change the position of the switches in the secondary circuit of the autotransformer. If the tube is under load and the switches are moved, either one of two things may occur, depending upon the construction of the switches. With one type of switch, as the connector switch point moves from one tap to another a section of the transformer winding is short-circuited. As this circuit is of low resistance, a heavy current flows, which is broken as the switch continues to move onward. Since this results in an arc, which is destructive of the switch points, this practice is undesirable. This arc may be prevented by increasing the space between the points so that the short-circuiting of the transformer winding is avoided. This practice makes and breaks the circuit each time a point is crossed and the voltage on the tube is thus momentarily reduced to zero and then returned to its full value. This method is also unsatisfactory, inasmuch as it may cause destructive high-voltage surges.

Most installations now employ a resistance in series with the autotransformer (Fig. 1). When it is necessary to change the voltage on the tube, this resistance is increased to a maximum, reducing the voltage on the tube to such a value that the current in the primary circuit may be interrupted without danger. The tap switches on the autotransformer are then reset to the desired position and the resistance is slowly removed from the circuit, gradually bringing up the voltage on the tube to the proper value without surges. Unless technicians are well trained and under supervision, this procedure, which requires time, will not always be followed. As a result, it is necessary periodically to service and replace the switch points in the autotransformer circuit.

Two constant potential generators for therapeutic work are in use at the Los Angeles Tumor Institute. A 200-kv. unit supplies two oil-cooled 200-kv. therapy

[1] From the Los Angeles Tumor Institute, Los Angeles, Calif. Accepted for publication in April 1941.

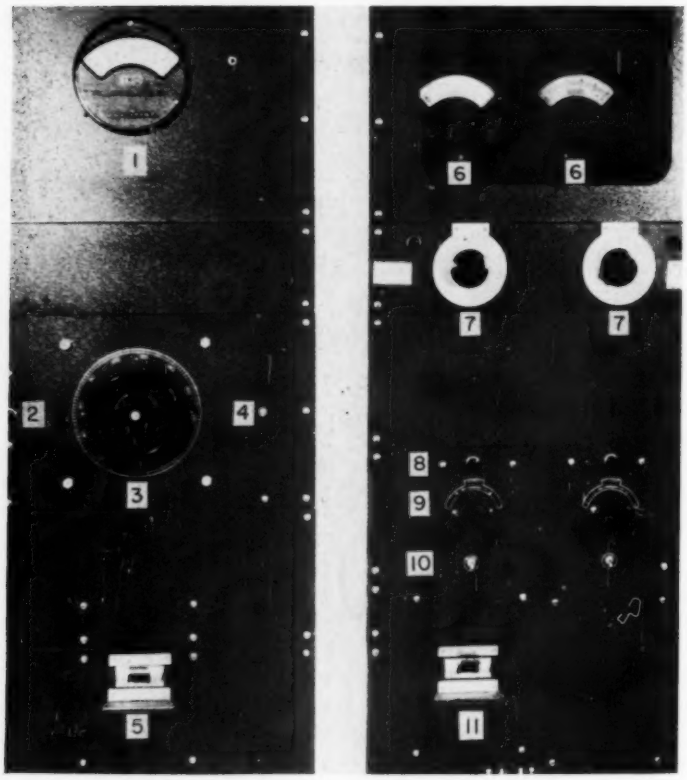

Fig. 3. Installation at Los Angeles Tumor Clinic.
1. Primary voltmeter. 2. Red signal lamp (x-ray on). 3. Variac control handle and dial. 4. X-ray switch. 5. Line switch (200,000-volt set). 6. Milliampere meters. 7. Treatment timers. 8. Amber signal lamps (filament on and high-tension switch closed). 9. Filament regulating reactance. 10. Switches to turn on filament and close high-tension switch. 11. Main line switch.

tubes, normally operated at 4 to 6 milliamperes, and a 100-kv. unit is employed to supply two oil-cooled 100-kv. units, operated at 4 milliamperes. Inasmuch as there is considerable switching of the autotransformer on even an average day at the Institute, some method of simplifying the procedure was indicated. A new type of autotransformer of sufficient power-handling capacity for therapeutic use has recently been placed on the market under the trade name of "Variac," by the General Radio Corporation of Cambridge, Massachusetts. These units operate on the familiar autotransformer principle, but have the advantage that the variable tap of the secondary coil may be moved from point to point, short-circuiting successive turns of the winding through a carbon brush. This brush has a sufficiently high resistance to keep the short-circuit current at a low value, but nevertheless not enough resistance results in the secondary circuit to be of significance.

This new type of autotransformer has, therefore, two important advantages: (1) the secondary voltage from the autotransformer can be varied under load without destruction of the movable contact points and (2) a continuous variation of secondary voltage is possible as the movable contact goes from turn to turn of the winding. The change in voltage as the contact moves from one turn to the next

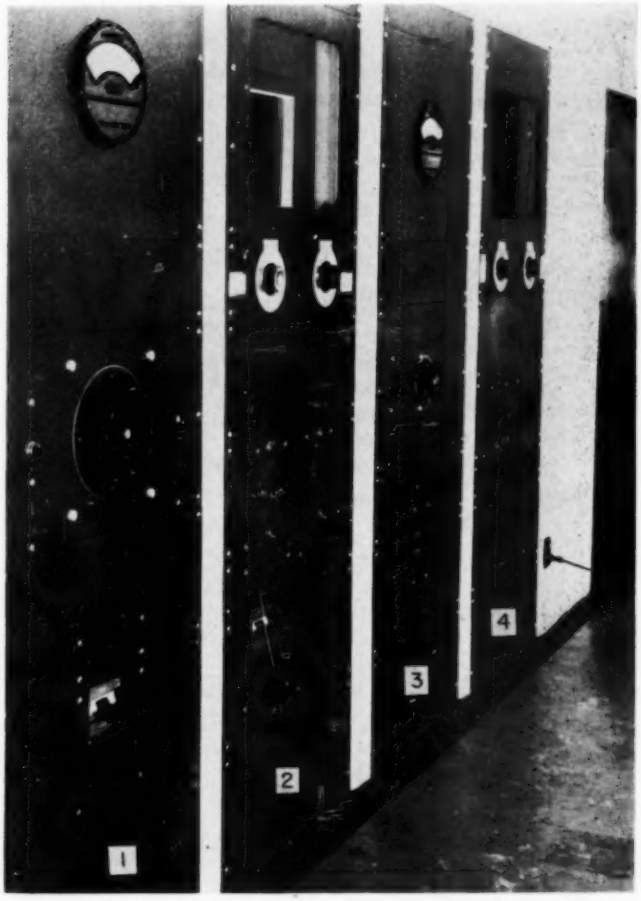

Fig. 4. Installation at Los Angeles Tumor Clinic.
1 and 2. 200,000-volt control panels. 3 and 4. 100,000-volt control panels.

depends only upon the number of turns in the winding.

The method of procedure in the operation of the therapy tube is consequently much simplified. The customary resistance in series with the autotransformer may be omitted (Fig. 2). The variable tap of the transformer is set for zero secondary voltage and the primary switch is closed, energizing the autotransformer. The movable contact is then swept along the coil to the point giving the desired voltage on the x-ray tube. At the same time, the filament regulator is adjusted to obtain the proper milliamperage through the tube. If at any time it is necessary to change the voltage, the movable contact may be shifted without breaking the circuit or interrupting the treatment. When the treatment is terminated, the movable contact is returned to the zero position and the primary circuit is then interrupted by the x-ray switch.

Photographs of the installation at the Los Angeles Tumor Institute are shown in Figures 3 and 4. A 7 1/2-kva. Variac was used for the 200-kv. unit and a 2 1/2-kva. Variac for the 100-kv. unit.

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Two Instruments for Measuring X-Ray Tube Voltage[1]

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THE USE OF A cathode-ray oscillograph to measure peak voltages and to study the wave form of the voltage applied to x-ray tubes, and the employment of a thyratron peak voltmeter to measure peak voltages have been discussed and the instruments have been described by Weyl (1, 2, 3) and his co-workers. A calibrating device for use with an oscillograph and a vacuum tube peak voltmeter which, since the filament of the tube is heated by alternating current, is easily portable, are described here. Both instruments have been in use for the past year and a half.

The complete wiring diagram of the equipment used with the oscillograph is shown in Figure 1. The entire equipment except the resistors R_1 and R_2 is contained in a metal box measuring 6 1/2 × 7 1/2 × 8 inches (17 × 19 × 20 cm.). R_1 and R_2 have been made up from International Resistance Company type MV high-voltage resistors, although any high-voltage resistors could be used. Each resistor unit contains 50 megohms and the units can be connected together so that the resistance of R_1 or R_2 is 50, 100, or 150 megohms. One end of each resistance is connected to the high-voltage system with clamps and the other end is connected to r_1 and r_2 with shielded cables.

By means of the double-pole double-throw switch S_1 the oscillograph can be connected either to the high-resistance voltage divider (position X) or to the potentiometer P_1 (position B). When the switch is in position X, the voltage applied to the oscillograph, V_2, is approximately the same fraction of the voltage applied to the x-ray tube, V_1, as the resistance $r_1 + r_2$ is of the total resistance $R_1 + R_2 + r_1 + r_2$. When the switch is in position B, the voltage applied to the oscillograph is approximately that indicated by the voltmeter, VM. To compute the true voltage applied to the oscillograph it would be necessary to take into account that part of the resistance of the potentiometer, P_2, contained in the circuit and a resistance inside the oscillograph connected between the two plates. Neglecting these resistances, however, introduces an error of

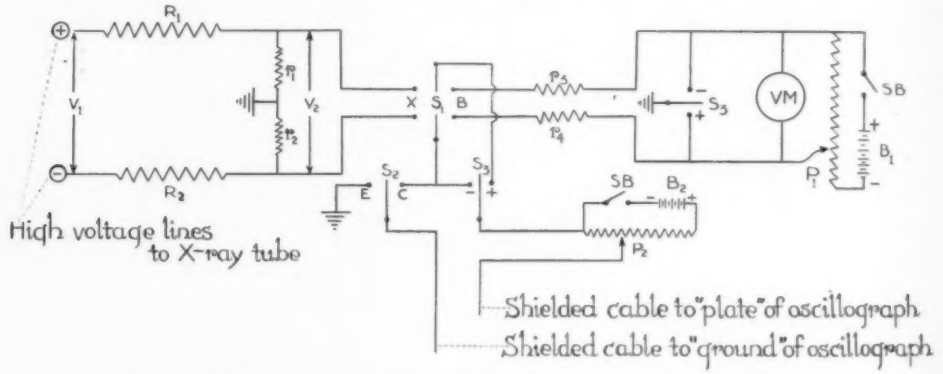

Fig. 1. Circuit for measuring high voltages with a cathode-ray oscillograph. $R_1 = R_2$ = 50 to 150-megohm high-voltage resistors; $r_1 = r_2$ = 50,000 ohms; $r_3 = r_4$ = about 50,000 ohms; P_1 = 10,000-ohm potentiometer; P_2 = 25,000-ohm potentiometer; S_1 and S_3 = DPDT switches; S_2 = SPDT switch; SB = DPST switch; B_1 = 100 volts; B_2 = 45 volts; VM = 0–100-volt voltmeter.

[1] Accepted for publication in March 1941.

less than 0.5 per cent because of the presence of resistances r_3 and r_4 in the potentiometer circuit. The switch S_3 makes it possible to connect the oscillograph across $r_1 + r_2$, position C (center grounded), and thus to measure the total potential across the x-ray tube; or to connect the oscillograph across either r_1 or r_2, position E (end grounded), and to measure the potential from either side of the x-ray tube to ground, the side measured being determined by the position of the switch S_3. The switch S_3 also changes the ground connection in the potentiometer circuit, P_1, so that there is approximately the same resistance between the oscillograph and ground for all positions of switches S_1 and S_2. When switch S_2 is in position C, the case of the oscillograph is not at ground potential and so must be insulated from ground; however, since this potential difference is always small, there is no danger from a shock if the operator should touch the oscillograph.

Since the connections to the oscillograph are made directly to the vertical deflection plates and not through the amplifier, the oscillograph does not have an adjustment for the position of the zero voltage trace. The potentiometer circuit P_2 was included for this purpose.

With some oscillograph tubes the position of the zero voltage trace varies with the amount of resistance between the two plates, but in this circuit the resistance is kept practically constant for either position of switch S_1 by having the resistance of r_3 and r_4 approximately equal to that of r_1 and r_2.

The procedure for determining the peak voltage across an x-ray tube is to throw switch S_1 to position X, set switches S_2 and S_3 to the correct position to obtain either the total voltage across the tube or the voltage from either side of the tube to ground, note the deflection of the peak of the voltage wave on the oscillograph, throw switch S_1 to position B, and adjust potentiometer P_1 until the trace on the oscillograph is deflected the same distance as the previously noted deflection of the peak voltage. The peak voltage across the x-ray tube is then as many times greater than the voltmeter reading as the resistance of $R_1 + R_2 + r_1 + r_2$ is greater than the resistance of $r_1 + r_2$. Since r_1 and r_2 are very small compared to R_1 and R_2, no appreciable error will be introduced if the value $R_1 + R_2$ is used instead of the value $R_1 + R_2 + r_1 + r_2$. If the voltage from one side of the tube to ground is being measured, the ratio of R_1 (or R_2) to r_1 (or r_2) should be used, but this ratio is the same as that of $R_1 + R_2$ to $r_1 + r_2$. If only peak voltages are to be determined, or if only short exposures can be used, the sweep circuit of the oscillograph can be turned off, but if it is desired to study the wave form of the voltage, the sweep circuit must be used.

The wiring diagram for the vacuum tube peak voltmeter is shown in Figure 2. All this equipment except the resistors R_1 and R_2 is contained in a metal box measuring 12 1/2 × 9 1/2 × 5 1/2 inches (32 × 24 × 14 cm.). The high-voltage resistors R_1 and R_2 are the same ones used for the oscillograph measurements. The filament of the 885 grid-controlled, gas triode tube can be heated by an alternating current instead of a storage battery because the filament is separate from the cathode and an alternating potential on the filament does not affect the starting of the cathode plate current. The principle of operation of the circuit is practically the same as that described by Weyl (2). Plate current through the tube is indicated by a glow inside the tube. The resistance r_3 serves to limit the plate current. Some difficulty was experienced with the switch S_5, which serves to stop the plate current, because the change in capacity produced by closing the switch would often start the plate current when the grid potential was near the critical value. This difficulty was satisfactorily solved by using a "low-capacity switch" and shunting it by the condenser C in series with the resistance r_4; the values of the capacity and resistance were determined by trial and error and were not particularly critical.

The zero adjustment can be made either while the x-ray machine is not being operated, or, if the x-ray machine is being operated, with the switches S_1 and S_2 in the G position so that resistances r_1 and r_2 are not included in the voltage divider circuit. With potentiometer P_2 set so that it does not apply voltage to the cathode-grid circuit (voltmeter reading zero) and with switch S_5 closed, the slider of potentiometer P_1 is set so that the slightest motion to the right will start the plate current in the tube. Any additional positive potential applied to the grid of the tube will then start the plate current. The slider of potentiometer P_2 is then moved to the right and switches S_1 and S_2 are thrown to the positions + and −, respectively. When the x-ray machine is operated there will be a current flowing through $R_1r_1r_2R_2$. This current will produce a potential, V_2, across r_1 and r_2 which will be the same fraction of the potential across the x-ray tube, V_1, as the resistance $r_1 + r_2$ is of the resistance $R_1 + R_2$ (more correctly $R_1 + R_2 + r_1 + r_2$, but since $r_1 + r_2$ is very small compared to $R_1 + R_2$ the simpler expression does not introduce an appreciable error). The potential developed by the current flowing through r_1 and r_2 makes the grid more positive and will start the plate current unless an equal or greater positive potential is applied to the cathode by potentiometer P_2. If P_2 is adjusted so that the minimal potential which will prevent starting of the plate current is applied to the cathode, then this potential, which is indicated by the voltmeter, is just equal to the maximal potential developed in the resistance $r_1 + r_2$, and is the same fraction of the potential across the x-ray tube as the resistance $r_1 + r_2$ is of the resistance $R_1 + R_2$. Once the plate current is started it continues to flow regardless of the grid potential, and can be stopped only by opening switch S_5, but will start again when this switch is closed unless the difference in potential between the cathode and the grid is less than the critical starting potential. A change in grid potential of less than 0.05 volt determines whether or not the plate current will start.

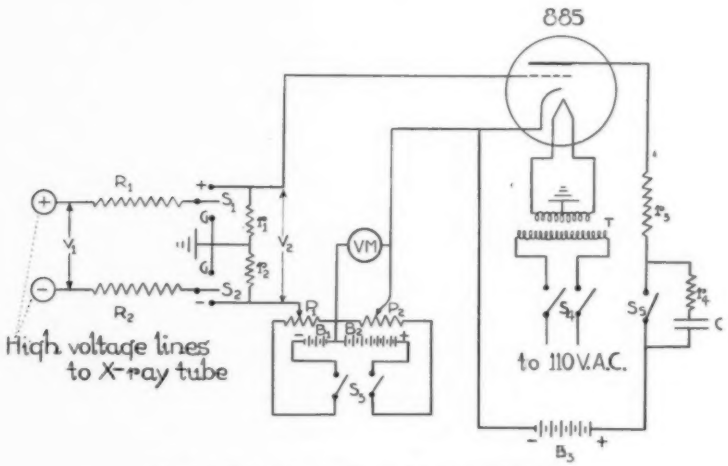

Fig. 2. Circuit for vacuum tube peak voltmeter.
Tube = 885 grid-controlled, gas triode; $R_1 = R_2 = 50$ to 150-megohm high-voltage resistors; $r_1 = r_2 = 25{,}000$ ohms; $r_3 = 20{,}000$ ohms; $r_4 = 500{,}000$ ohms; $C = 0.5$ microfarad; $P_1 = 5{,}000$-ohm potentiometer; $P_2 = 10{,}000$-ohm potentiometer; $B_1 = 22.5$ volts; $B_2 = 50$ volts; $B_3 = 90$ volts; $T = 2.5$-volt filament transformer; S_1 and S_2 = SPDT switches; S_3 and S_4 = DPST switches; S_5 = SPST (normally closed) "low capacity switch"; VM = 0–50-volt voltmeter.

The potential from either side of the

x-ray tube to ground can be measured by leaving the opposite switch, S_1 or S_2, in the G position. When potentiometer P_2 is adjusted properly, the reading of the voltmeter will be equal to the maximal potential developed in either r_1 or r_2 and will be the same fraction of the potential from one side of the x-ray tube to ground as the resistance of r_1 (or r_2) is of the resistance R_1 (or R_2).

Both of these methods of measuring x-ray tube potentials have been very satisfactory. The vacuum tube peak voltmeter, since it does not require heavy batteries, is easily transportable and is capable of determining peak voltages accurately and quickly. It is not affected by changes in atmospheric temperature, pressure, or humidity, which is an advantage over using a sphere gap. However, it measures only peak volts. Measurements made with the oscillographic equipment are in general easier and quicker to make. The oscillograph also offers an opportunity for observing the voltage wave form, which often is of more value than determinations of the peak voltage.

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Tube Ratings and Exposure[1]

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IN THE DEVELOPMENT of some of the newer methods in radiography, principally kymography and fluorography, the limits of technic are frequently set by the rating of the available tube. Not only in these special methods, but also in general, radiography is improved if the full ratings of the tube are utilized. The information is usually given by the tube manufacturer in the form of graphs or nomograms relating the voltage, current, and exposure time. From these charts can be discovered the maximum permissible value of any one of these variables for a given combination of the other two. The practice in developing new technic has been to determine the voltage, current, and time necessary, and then to check with the rating charts to see if the selected combination is permissible.

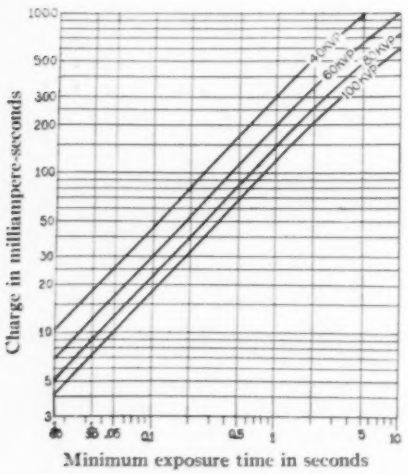

Fig 1.

The determination that a selected combination of factors is permissible is not, however, the solution to the problem. It may be possible to shorten the exposure time and raise the current, keeping charge (milliampere-seconds) constant. This will reduce movement unsharpness and should usually be done if the tube ratings are not thereby exceeded. The determination of the least exposure time or the maximum current permissible with any given charge and voltage is a task which should be easily accomplished with the use of the rating charts.

For this reason rating charts would be of more direct application if, instead of relating voltage, current, and time, they were constructed to relate voltage, charge, and time. The time, instead of being the *maximum* permissible for given combinations of voltage and current, would in such charts be the *minimum* permissible for given combinations of voltage and charge (milliampere-seconds).

Figure 1 is the rating chart of a well known tube (4.2-mm. focus) for full-wave excitation recalculated to the new variables, with double logarithmic co-ordinates. From it the usual problems of technic are directly answerable.

The information given in this chart may be condensed into a single line graph if, instead of charge as variable and kv.p. as parameter, energy is introduced as the variable. Then a new parameter, for example focal spot size, may be introduced, and there results a chart such as is shown in Figure 2. This graph represents the data for all the tubes of a series produced by one of the tube manufacturers, in a form to show directly the limitations of each focus size. It shows how the focus size determines exposure time for radiography of any part. For example, radiography of the gallbladder requires, let us say, 150 milliampere-seconds at 80 kv.p. This is 12 units of energy (kv.p. × amperes × seconds). As is shown by the chart, for this value of energy exposures of 6, 2.5,

[1] Accepted for publication in December 1940.

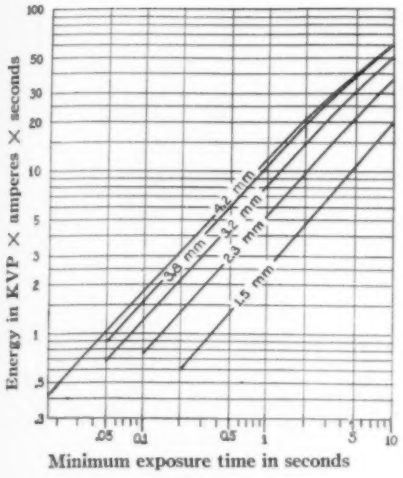

Fig. 2.

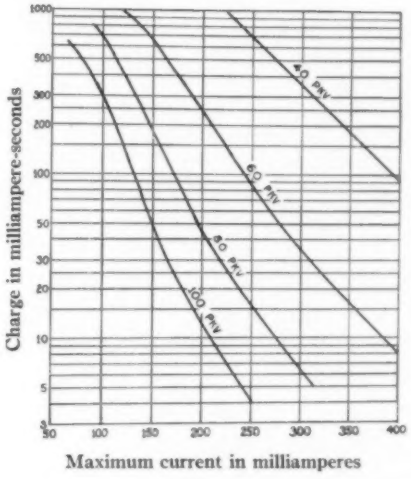

Fig. 3.

1.5, 0.9, and 0.8 seconds are required for tubes of 1.5, 2.3, 3.2, 3.8, and 4.2-mm. focal spot size, respectively.

Charts of this type, with either charge or energy as a variable, seem to be more logical and better suited for application than the charts heretofore supplied. It may be objected that the use of *minimum* exposure time as a variable is misleading, since the untrained person may assume that the tube may be used for a longer time, with the same settings (voltage and current). To overcome this difficulty and maintain the advantage of charge (or energy) as a variable, the chart may be constructed with *maximum current* instead of minimum time as the other variable. Figure 3 shows such a chart based on the ratings of Figure 1. Such a graph, while perhaps not as useful as those with minimum time as a co-ordinate, is nevertheless of considerably more direct application than is the usual type of rating chart.

SUMMARY

It is pointed out that the capacity ratings of x-ray tubes really determine the minimum exposure time permissible for a given exposure (milliampere-seconds and kv.p.). Rating charts showing the information required in more direct form than is usually given are suggested. They are graphs of charge (milliampere-seconds) against *minimum* exposure time with kv.p. as parameter, or of energy (kv.p. × amperes × seconds) against minimum time, with any useful parameter, such as focal spot size. The same variables (charge or energy) may also be plotted against maximum current to yield directly more useful information than is readily available in the conventional voltage, current, time charts.

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CASE REPORTS

Sacculated Aortic Aneurysm Report of a Case Mistaken for Mediastinal Tumor with Metastases[1]

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A case is presented of an unusually large aneurysm with small daughter aneurysms, with x-ray evidence of its existence for eight years, although it was undoubtedly present much longer. The patient died of an intercurrent infection of which no suspicion was aroused either clinically or roentgenologically before autopsy.

Daughter aneurysms are rather rare occurrences and in this case confused both the clinician and the roentgenologist.

CASE REPORT

On May 15, 1932, a 62-year-old white male was admitted to the San Francisco Hospital, comatose and unable to give a history. His wife stated that three days before entry he had come home from work with a chill, cough, fever, and chest pain. The past history was significant in view of the wife's statement that the patient had been well. He had never complained of pain, dyspnea, palpitation, or other symptoms referable to the cardio-respiratory system.

On physical examination, the chest showed an impaired percussion note over the right base anteriorly and the right apex posteriorly. Breath and voice sounds were increased over the right chest posteriorly, especially at the apex, and many coarse râles were audible over the entire thorax. The heart appeared enlarged to percussion, and there was a visible and palpable pulsation in the right second intercostal space. The heart tones were good and no murmurs were heard. There was a scar on the dorsum of the glans penis. Otherwise the examination was negative.

The red blood count was 5,000,000, with 85 per cent Hgb.; white cells 16,000, with 74 per cent polymorphonuclear leukocytes, and 26 per cent lymphocytes. The urine showed an occasional granular cast but no albumin or sugar. There was a right axis deviation and slight slurring in all leads of the electrocardiogram. The blood Wassermann was positive and the spinal fluid Wassermann was negative. The colloidal gold curve of the spinal fluid was 1110000000.

The roentgenogram (Fig. 1) showed a widening of the upper mediastinal shadow on the right. This shadow had a smooth convex border and was of the same density as the heart shadow. The latter was not enlarged, but the aortic knob was displaced to the left, as was the trachea. The right upper lobe showed an increased grayness and contained a few well calcified infiltrations. There was an area of mottling and haziness in the left base as well. Impressions from the roentgenogram were: (1) aneurysm of the ascending aorta with compression of the right upper lobe; (2) pneumonitis in the left base; (3) calcified obsolete tuberculous lesions in the right upper lobe.

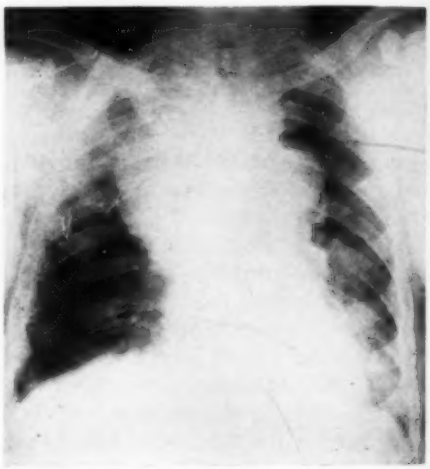
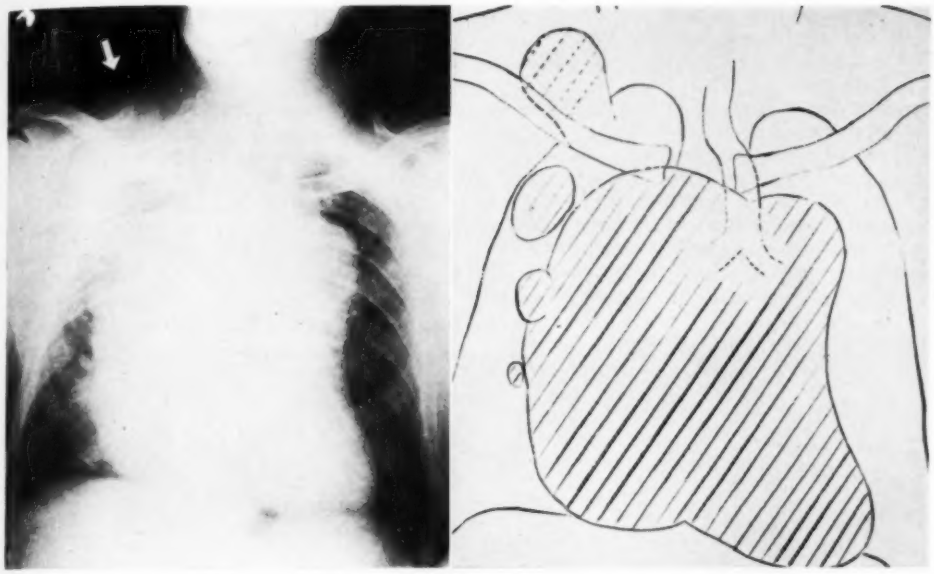


Fig. 1. Roentgenogram of chest taken May 18, 1932, showing the saccular aneurysm with compression of the right upper lobe. There is also a pneumonitis in the left lower lobe.

During his stay in the hospital the patient developed psychotic symptoms, which a neuropsychiatric consultant interpreted as a confusional state due to cardiac disease and pneumonia. The clinical diagnosis was bronchopneumonia, aneurysm of the ascending aorta, and exhaustion psychosis.

The patient was discharged and was not seen again until the time of his second entry, eight years later. During the interval, his relatives stated, he had not been entirely well but was able to get about. He had become irrational in the past eight to ten months and was occasionally disoriented as to time and place. His memory for recent events was poor and he had become definitely worse in the two months prior to admission. He complained of pain in his chest, back, and legs. He was short of breath and would not eat. He was treated at home, but his symptoms gradually increased in severity and he became weaker.

[1] From the University of California Service, Department of Radiology, San Francisco Hospital. Accepted for publication in June 1941.



Figs. 2 and 3. Roentgenogram taken July 10, 1940, and diagrammatic sketch, showing the tremendous increase in the size of the aneurysm with the small daughter aneurysms budding from it. Arrow indicates the supraclavicular extension.

The patient was readmitted to the San Francisco Hospital on July 10, 1940, irrational and semicomatose. His temperature was 101° F., pulse 90, respirations 28 per minute. He was emaciated and dehydrated and had a brassy cough and hoarse voice. There was a round mass, about the size of a large walnut, in the right supraclavicular area that was thought to be an enlarged lymph node. The trachea was displaced to the right. The chest showed an area of dullness anteriorly over the right upper lobe which, on palpation, could be felt to pulsate. The breath sounds were harsh and increased, and a few moist râles were heard at the bases of both lungs. The heart was enlarged to percussion; tones were poor; no murmurs were heard, but an occasional extrasystole was present. The blood pressure in the right arm was 90/60 and in the left 80/60. The liver was enlarged two fingers beneath the right costal margin.

The red blood count at this admission was 4,750,000, with a hemoglobin of 98 per cent. The white blood count was 5,950 with 80 per cent polymorphonuclears and 20 per cent lymphocytes. The urine was normal and the Wassermann and Kahn tests were negative. The electrocardiogram showed a left axis deviation, occasional ectopic beats, and an interventricular conduction defect.

At this time the roentgenogram (Fig. 2) showed a mass with a smooth convex right border extending from apex to base and reaching into the lung to the mid-clavicular line on the right. The aortic knob and heart shadow were displaced to the left, as was the trachea. Several large smooth nodules were seen in the right lung just beyond the convex right border of the tumor. There was an increased density of the right upper lobe which was greater than at the examination eight years previously. There was also an erosion of the second rib. On fluoroscopic examination, no pulsations were seen in the tumor. The roentgenologic interpretations were: (1) large aneurysm of the aorta; (2) possible multiple metastases in the lung; (3) atelectasis of the right upper lobe. The clinical diagnoses were: (1) superior vena cava block; (2) aortic aneurysm; (3) supraclavicular tumor.

Autopsy: Upon opening the thorax, a mass was encountered directly underneath the sternum, filling the upper two-thirds of the right hemithorax and displacing the mediastinal contents to the left. The right lung was compressed backward and downward, the right upper lobe being completely atelectatic. The right lower lobe was well aerated. Dissection showed the mass to extend upward beneath the clavicle and on top of the first rib, continuous with the mass palpable in the right supraclavicular region. This mass was a huge aneurysmal sac, bounded by vessel wall. It was firmly adherent to the chest wall and heart. The second rib was eroded, so that only 4 cm. of its sternal border remained, and portions of the third rib also showed erosive changes.

As the mass was firmly attached to the heart and right lung, they were removed *en masse* (Fig. 4). The total weight was 2,620 gm. and, on section, a

large laminated hyalin clot was seen. As the extension of the aneurysm in the right supraclavicular region could not be removed, it was divided at the level of the clavicle. There were three daughter aneurysms of moderate size (2 to 4 cm.) extending from the surface of the aneurysmal sac. The pericardial sac was incised and was seen to be firmly adherent to the epicardium. The estimated weight of the heart was 350 gm. and the muscle walls and valves were normal. The aorta showed a combination of arteriosclerosis and syphilitic aortitis.

The microscopic findings were as follows: The heart muscle was normal. The lungs showed numerous large caseous tubercles bounded by giant cells, fibrous tissue, and lymphocytes. Occasionally, a young tubercle was seen in the right lung, while in the left, multiple small tubercles were present, no single tubercle being larger than an alveolus. The adrenals showed numerous young tubercles located in all zones of the cortex. Diffusely scattered miliary tubercles were present in both the liver and spleen. A medium-sized tubercle containing a central caseated area was found in each kidney. There was a tuberculous ulcer, also, in the ileum.

The autopsy diagnoses were: (1) syphilitic aortitis with aneurysm of the ascending aorta; (2) chronic fibrocaseous pulmonary tuberculosis with (*a*) caseous gelatinous pneumonia, (*b*) miliary spread to spleen, liver, kidneys, and adrenals, (*c*) tuberculous enteritis, (*d*) tuberculous pericarditis.

Fig. 4. Roentgenogram of postmortem specimen, consisting of the right lung, the heart, and the huge aneurysm. The site of the daughter aneurysms is indicated by the three black arrows. The white arrow indicates where the supraclavicular extension was divided. The right lung has been twisted to the left side to allow all three objects to be seen.

DISCUSSION

Osler has said, "There is no disease more conducive to clinical humility than aneurysm of the aorta. Mistakes occur with the most careful and the most skillful. Sometimes the diagnosis is beyond our art; most often it is not made because of the carelessness that so easily besets us in our work." It is surprising, sometimes, how large an aneurysm can become and still give rise to few or no symptoms. In the present case, the patient was quite senile and had apparently learned to live with his disease.

In considering mortality statistics, it is usual to divide cases into simple aneurysm, as in this instance, and aneurysm plus aortic insufficiency. Lamb and Turner (1) found, in cases of simple aneurysm, that at two years 74 per cent of patients were alive, 26 per cent dead; at ten years 10 per cent were alive and 90 per cent dead. In cases of aneurysm plus aortic insufficiency, at two years 51 per cent of patients were alive, 49 per cent dead; at ten years 4 per cent were alive, 96 per cent dead. Thirty-three per cent of the latter group (aneurysm plus aortic insufficiency) died of heart failure.

In a series of 1,749 autopsies done on the University of California Service of the San Francisco Hospital—1935 through 1940—66 cases of syphilitic aortitis were seen. In these 66 cases 16 aneurysms were found, only one of which showed daughter aneurysms. (Non-syphilitic aneurysms were not considered.) Ten of these cases were simple aneu-

rysm and 6 were aneurysm plus aortic insufficiency. All 6 patients with aortic insufficiency died from myocardial failure; of those without insufficiency, 3 died from rupture, 3 from miliary tuberculosis, 1 from hypertensive cardiovascular disease and congestive failure, 1 from aortic thrombosis, 1 from malignant neutropenia, and 1 from arteriosclerotic heart disease.

A search of the literature indicates that cases of aneurysm plus daughter aneurysms are rare. They are not described by MacCallum, Boyd, Reimann, or Delafield and Prudden. Carr (2), however, estimates the incidence as 10 per cent of aneurysms found at autopsy. Multiple aneurysms are reported, but in all these cases each aneurysm arose from the aorta and not from an aneurysmal sac.

The weakness of our patient at the time of the last entry could well be explained by the fact that the adrenals were the site of miliary tuberculosis. Another interesting item is the fact that, whereas a blood Wassermann was positive in 1932, in 1940 it had become negative, and this without treatment. It is not unusual for an aneurysm to be treated with x-rays before the diagnosis has been made, although this was not done in the present case. Such a therapeutic test may be the means of diagnosing a mediastinal lymphoblastoma, which simulates an aneurysm. The lack of pulsations during fluoroscopy was due to the presence of the large hyalin clot. This is not an unusual finding. Nichols, Ostrum, and Widmann (3) state that, in their experience, differentiation between expansile pulsation and motion transmitted from the heart has been impossible, except in isolated instances.

Note: Grateful acknowledgment is made to Drs. Robert S. Stone and L. H. Garland for their help and advice.

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Fecalith of the Rectum: Report of a Case Simulating a Neoplasm[1]

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In the radiologic investigation of the colon, fecalith of the rectum is a rare observation. Rectal impaction of feces, barium, or foreign body is, however, often seen by the proctologist. The general incidence of rectal fecalith has not been established, nor has the roentgenologic incidence been investigated. I have encountered but a single instance in many thousands of colon examinations. Nothing is mentioned in the textbooks regarding the roentgen diagnosis of rectal fecalith and even the roentgen literature contains very little on this condition.

Fecal impaction is frequently the cause of symptoms simulating rectal disease. It is easily recognized by means of the proctoscope, but it has not often been demonstrated roentgenologically. The condition may be misinterpreted as a neoplasm, since the radiologic appearance of the mass simulates that of a tumor. There are, however, a number of distinguishing radiologic signs of a fecalith which enable the roentgenologist to make a correct diagnosis. Fecaliths are generally large, and are usually single, rounded, and smooth in contour, in this respect simulating a benign growth. The mucosal markings of the rectum are not obliterated, which is an important roentgen sign in the elimination of an intraluminal neoplasm. Movability of the mass is indicative of a fecalith, but when the fecal accumulation is large, it may be difficult to detect mobility. Also, a pedunculated tumor may be movable, but this form of growth should produce a filling defect at the site of attachment. A fecalith produces no filling defect in the wall of the rectum.

Fig. 1. Roentgenogram following a colonic enema, showing a filled rectum with a large, smooth, rounded fecalith in the rectal ampulla.

The following case is typical roentgenologically of a rectal fecalith.

A woman, aged 78, complained of severe constipation and rectal discomfort. There were clinical manifestations of a partial obstruction. No bleeding from the rectum nor any other objective signs were observed which would lead one to suspect an organic

[1] Accepted for publication in October 1940.

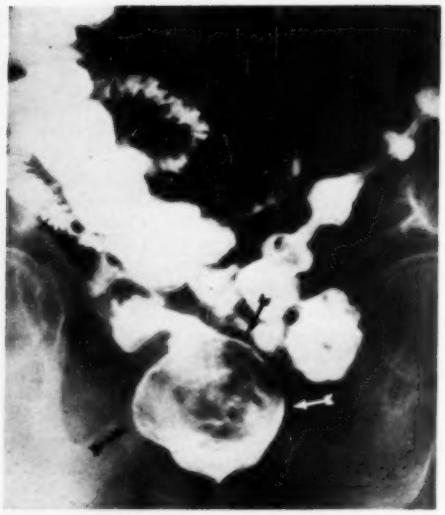

Fig. 2. Evacuation roentgenogram, showing characteristic signs of a rectal fecalith. After the excess of barium had been expelled, the smooth contoured mass and the rectal mucosal markings were shown.

lesion. Enemas were ineffectual. There was a feeling of constant distress in the left lower abdomen, with loss of weight, symptoms suggesting a possible malignant neoplasm. A roentgen examination of the colon by a barium enema revealed a large, smooth, rounded defect about 4.5 cm. in diameter, situated in the rectal ampulla. It appeared to be fixed in position. The mucosal markings of the rectum were intact. Although the defect simulated a benign tumor, it did not have the definite characteristics of a malignant growth. Proctoscopy revealed a large, smooth, hard mass, representing a single fecalith, which was broken up and removed.

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Unusual Fracture of Sesamum Peroneum[1]

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There are eleven accessory bones of the foot (1): os trigonum, os sustentaculum proprium, calcaneus accessorius, calcaneus secundarius, ossiculum trochleae, tibiale externum, cuboides secundarium, os intercuneiforme, sesamum peroneum, os intermetatarseum, and os vesalianum.

Of these eleven, only one is a sesamoid bone. The term "sesamoid" (from the resemblance to sesame seed) is applied to bones which are enclosed and located near the insertion of tendons in close contact with other bones. Sesamoid bones are divided into those which are constant and those which are inconstant in their occurrence. Examples of the former are those of the hallux, which are not included in the above list of accessory bones. The tibiale externum is considered by some to be a sesamoid bone in the tendon of the tibialis posticus. Pfitzner (2), however, claims it is never enclosed in a tendon. Dwight (3) found it to be a separate bone in 10 per cent of cases.

Fig. 1. Fracture of sesamum peroneum: roentgenogram taken Sept. 20, 1938.

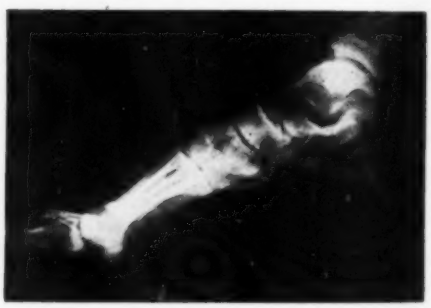

Fig. 2. Fracture of sesamum peroneum: roentgenogram taken Oct. 17, 1938.

Two of the accessory bones of the foot, when present, are found in the plantar portion of the longitudinal arch. The os vesalianum is at the base of the fifth metatarsal and the sesamum peroneum at the posterior edge of the cuboid in the peroneus longus tendon. The other bone in this location is the epiphysis of the fifth metatarsal, which is ununited up to the fourteenth to twenty-second year, when normal fusion takes place. The appearance of an os vesalianum in an adult may be only a result of a lack of fusion of the epiphysis.

The sesamum peroneum was found in 5 per cent of individuals by Bizarro (4), in less than 10 per cent by Dwight, and in 6 per cent of a personal series of 200. The possibility of fracture of this bone by direct trauma cannot be great, as no previous case could be found in the literature. In the patient to be described, no known injury occurred other than weight-bearing.

A fracture of this bone might be confused with

[1] Accepted for publication in January 1940.

an avulsion of the anterior inferior portion of the os calcis. There are two distinguishing features: the difference in density and the later absorption of the posterior portion. In avulsion of the anterior portion of the os calcis, no such absorption would take place as occurred in this case.

CASE REPORT

I. S., a white male, aged 34, was examined Sept. 20, 1938. His chief complaint was pain in the arch of the foot, which had appeared one week earlier after the weight had been suddenly thrown on this part of the foot at the edge of a street curbing. X-rays revealed a fracture of a peroneal sesamoid through the center. This bone measured 10 mm. × 15 mm. and was located just under the posterior margin of the cuboid. There was a 5-mm. separation of the fragments. Treatment by cast for four weeks produced satisfactory results. The diagnosis of fracture was made certain by the irregular edges of the adjacent surfaces, and by the changes shown in the later films taken Oct. 17, 1938, and July 9, 1939. The last film shows almost complete absorption of the posterior fragment.

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Washington, D. C.

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(Photograph by C. Bennette Moore)

LEON J. MENVILLE, M.D.

President of The Radiological Society of North America

EDITORIAL

Howard P. Doub, M.D., Editor

John D. Camp, M.D., Associate Editor

Leon John Menville, M.D.

With the Twenty-seventh Annual Meeting of the Radiological Society of North America Dr. Leon John Menville assumes the presidency. For RADIOLOGY it is a special pleasure to welcome its former editor to this high office. His scientific attainments and widespread influence as an editor have made his name known throughout the medical world.

Dr. Menville was born in Napoleonville, Louisiana, in 1882. His academic training was received in Louisiana State University, and later he attended the Medical College of Baltimore, from which he was graduated with the degree Doctor of Medicine in 1904. After graduation Dr. Menville began practice with his father, Dr. Charles M. Menville, in Houma, Louisiana. In 1905 the young doctor installed roentgen equipment in his office and from that year his interest, time, and energy have been devoted to the art of radiology.

Dr. Menville became a member of the Radiological Society of North America in 1920, and has occupied a prominent place in its councils, serving on various committees and as Vice-President on two occasions. From June 1931 to February 1941 he was Editor of RADIOLOGY, which under his guidance maintained a uniformly high standard of quality that has kept it in the front ranks of contemporary medical literature.

Dr. Menville is a member of the Orleans Parish Medical Society; the Louisiana State Medical Society, of which he is a past president; the Southern Medical Association; and the Society of Experimental Biology and Medicine. He is also a member of the American Roentgen Ray Society and the American Radium Society. He is a Fellow of the American Medical Association and is a delegate to that body, representing the Louisiana State Medical Society. In 1923 he was elected to Fellowship of the American College of Radiology and has served as its Vice-President.

Honorary membership has been bestowed upon Dr. Menville by the National Academy of Medicine of the Republic of Colombia. He is also a member of Omicron Delta Kappa and of Alpha Omega Alpha, honorary medical fraternity. He has held a commission as Lieutenant-Commander, U. S. Naval Reserve, since 1928, and has served for many years as a Consultant in Roentgenology at U. S. Veterans' Hospital No. 84. In addition to his duties in private practice, Dr. Menville has been Chief of the Department of Radiology in the Hutchinson Memorial Clinic of Tulane University since its organization in 1933. He has been Professor of Radiology in the School of Medicine, Tulane University, since 1934. In 1940 he was appointed Director of the Department of Radiology of Charity Hospital of New Orleans.

Dr. Menville has made many contributions to medical literature. Some of the most outstanding have had to do with his experimental work on the emptying of the visualized gallbladder, the motility of the gastro-intestinal tract, and the roentgen visualization of the lymphatic system. In recognition of his studies of the lymphatics he was awarded the Gold Medal of the Radiological Society of North America in 1932, and the Gold Medal of the Louisiana Academy of Sciences in 1934.

The Society is to be congratulated in having this distinguished physician as its president.

The Radiologist and the War

Our nation in conjunction with the other democracies of the world is now at war against the forces of dictatorship and oppression. Whatever differences of opinion may have existed between us regarding the advisability of entrance into this conflict were fused into a national solidarity by the explosion of the first bomb on American soil.

The carrying on of the war to a successful conclusion demands great sacrifices by the radiologists of this country. Many of the members of our Society are already in the Military or Naval Service of the nation and many more are in the Reserve Corps awaiting their call. In this present emergency the American radiologists will unhesitatingly and wholeheartedly respond as they have done in the past. In time of peace the physician is motivated by a spirit of humanitarianism; to this is added in time of war patriotic devotion to his country.

Heavy duties will also be imposed on those who remain at home in civilian work. A greatly augmented training program must be instituted to increase the number of men available for military radiology. Some method should also be developed to safeguard the professional interests of those who are serving their country in the Army and Navy. This matter has already been the subject of consideration by the American College of Radiology, and its Resolution on the subject appeared in an earlier issue of this Journal.[1]

Committees are already at work looking toward a closer co-operation between the radiologists and our armed forces. Radiologically great strides have been made since the last World War, but the essential requirements are still the same: a qualified radiological staff, well trained and capably supervised, in active service and a redoubled effort on the part of those not in the military or naval forces that civilian radiology shall not suffer too greatly as a result of the withdrawals from its ranks.

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[1] Radiology **37**:110, July 1941.

RADIOLOGY is desirous of obtaining a list of all radiologists in the military and naval services, with their commissions. Subscribers are asked to co-operate by sending such information to the Editor, Dr. Howard P. Doub, The Henry Ford Hospital, Detroit, Michigan.

RADIOLOGICAL SOCIETY OF NORTH AMERICA

TWENTY-SEVENTH ANNUAL MEETING, SAN FRANCISCO
DEC. 1–DEC. 5, 1941

THE SCIENTIFIC PROGRAM

Members of the Radiological Society of North America, who are accustomed to good programs, found at the Twenty-seventh Annual Meeting in San Francisco a program the equal of any that they have heard, and one that included several novel features which should be repeated. The combination of panel discussion and symposium, which was first used in San Francisco, has certain advantages both over a formal symposium and over an informal round-table discussion. Though some minor faults appeared, these can easily be eliminated from future programs, and the advantages of this method of presenting a subject are so many that it should be continued.

There were an unusual number of fine symposia. The opening one, on brain tumors, was arranged by Dr. John Camp of Rochester, Minnesota, and introduced by Dr. Edwin B. Boldrey of San Francisco with an outline of the pathology of brain tumors, which he correlated with the roentgen findings. Dr. Boldrey's paper was followed by an interesting statistical survey of the reliability of localization by Dr. Fred J. Hodges and Dr. Vincent C. Johnson from Ann Arbor. Next came an excellent review of intracranial calcifications of non-neoplastic origin by Dr. Camp, a paper of great practical value. Dr. Eldwin R. Witwer of Detroit then read an interesting paper describing the application of electroencephalography and the petrographic microscope to the study of brain tumors. As Dr. Witwer and his co-authors—A. J. Derbyshire, Jr., and Kenneth E. Corrigan, also of Detroit—pointed out, though they are not now generally available to physicians, nor are they sufficiently understood to be of practical value, both methods of study hold promise of useful future developments.

In the Monday afternoon diagnostic section Dr. Frank S. Dolley and Dr. Lyman A. Brewer of Los Angeles presented a timely discussion of intrathoracic tumors. This was followed by a symposium on fungous infections of the lung, bone, and gastrointestinal tract, arranged by Dr. L. Henry Garland of San Francisco. This was a good deal to cover but it was successfully done by Dr. Charles E. Smith, of San Francisco, speaking on "Parallelism of Coccidioidal and Tuberculous Infections;" Dr. Robert A. Powers, Palo Alto, on "Roentgen Findings in a Group of Cases of Primary Coccidioidomycosis;" Dr. Ray A. Carter, Los Angeles, on "The Roentgen Diagnosis of Fungous Infections of the Lungs with Special Reference to Coccidiomycosis;" Dr. Albert K. Merchant, Stockton, on "The Roentgen Diagnosis of Fungous Infections of the Intestinal Tract;" and by Dr. Carl D. Benninghoven of San Mateo and Dr. Earl R. Miller of San Francisco on "The Roentgen Diagnosis of Coccidioidal Infections in Bone."

The therapy section on Monday afternoon was devoted to a symposium on cancer of the breast arranged by Dr. William E. Costolow of Los Angeles. Dr. Lowell Goin opened the program, discussing the general management of the patient with cancer. This is an important subject, for as Dr. Goin pointed out we are apt to forget the patient in our interest in the cancer. Next came Dr. Frederick W. O'Brien's paper on "The Place of Irradiation in Cancer of the Breast." He recommended no one procedure as being the best, but advised that each patient should have surgery, irradiation, or both, depending upon the conditions, as neither the surgeon nor the radiologist knows all the answers. A similar position was taken later in the symposium by Dr. Alson R. Kilgore of San Francisco, speaking from the surgeon's point of view. It was good to hear this problem approached with sanity rather than partisanship. Dr. John W. Budd of Los Angeles presented a beautiful survey of the pathology of breast tumors, illustrating his talk with as fine and as readable photomicrographs as we have been privileged to see. Dr. Albert Soiland spoke on preoperative irradiation. The symposium closed with a paper on "Radiation Osteitis of the Ribs," by Dr. Lester W. Paul and Dr. Ernst A. Pohle of Madison, Wisconsin.

Tuesday morning was filled by a symposium on inflammations, arranged by Dr. Eugene Pendergrass. This was opened by Dr. A. U. Desjardins, who spoke on "The Mode of Action of Roentgen Rays on Inflammatory Conditions." Following this, Dr. James P. Rousseau of Winston-Salem reported upon the successful treatment with roentgen rays of 22 out of 29 patients with pneumonia who did not respond to sulfonamide therapy. Dr. Walter C. Popp and Dr. Henry L. Williams of Rochester, Minnesota, came next with a report of gratifying results in the treatment of acute sinusitis. Dr. Robert Fricke and Dr. Gordon F. Madding of Rochester reported on the treatment of postoperative parotitis with radium, and Dr. James Kelly of Omaha on "The X-Ray for the Prevention and Treatment of Acute Spreading Peritonitis." The symposium was closed by Dr. Pendergrass and

The Pfahler Gavel is passed on by President Wasson to incoming President Menville.

Dr. Philip J. Hodes, who spoke on roentgen therapy of postoperative parotitis. They showed an excellent moving picture covering the diagnosis and treatment. Everyone who was fortunate enough to see this picture was convinced of the value of moving pictures in illustrating medical subjects.

In the diagnostic section on Tuesday a paper on dental roentgenology by Dr. Gordon Fitzgerald of San Francisco was followed by a symposium on the gastro-intestinal tract, with attention chiefly to infants and children. The essayists were Dr. A. L. L. Bell of Brooklyn, Dr. John S. Bouslog of Denver, Dr. Samuel G. Henderson and Dr. W. W. Bryant of Pittsburgh, and Dr. Charles S. Capp and Dr. William C. Deamer of San Francisco. The symposium was followed by two papers on lesions of the lower spinal region: one by Dr. John B. de C. M. Saunders and Dr. Verne T. Inman of San Francisco; the other by Dr. Bernard H. Nichols of Cleveland. Drs. Saunders and Inman brought out interesting developments in relation to the cause of pain in ruptured discs. Dr. Nichols advised against hasty and radical surgery in these patients.

The Tuesday program in the therapeutic section, except for papers by Dr. A. U. Desjardins on "Problems in Roengten Therapy for Hodgkin's Disease and Lymphosarcoma," and Dr. Rollin H. Stevens on "Radium Poisoning," consisted of an unusual panel discussion on the leukemias and lymphoblastomas arranged by Dr. Robert R. Newell. The participants were Dr. John H. Lawrence of Berkeley, Dr. Harold P. Hill, Dr. Ernest H. Falconer, Dr. David A. Wood, and Dr. Harry A. Wyckoff, all of San Francisco. Dr. Newell acted as interlocutor, posing various questions to this group of experts. The discussion was informal and comprehensive. Differences of opinion appeared which were informative and stimulating. The opportunity afforded by this type of presentation for a free interchange of ideas between various specialists proved of great value.

The Carman lecture, "Fluoroscopes and Fluoroscopy," was given by Dr. W. Edward Chamberlain of Philadelphia. This was in many ways one of the most outstanding of the Carman lectures. Dr. Chamberlain showed his originality by choosing as his subject an instrument which most of us take for granted. His studies included not only the fluoroscope itself but the eye of the operator, which is as important a part of the fluoroscope as the screen. He not only showed us how much we don't know about one of our most important tools but indicated the course of future developments.

Dr. Robert S. Stone arranged an impressive symposium on the cyclotron for Wednesday morning. This was one of the outstanding sections of the program, presenting new scientific material and offering hope for spectacular developments in physiology as well as therapy. On the afternoon of the same day about half of those registered visited the cyclotron. The trip was delightful; the California sun was at its best. We were taken to see the enormous new cyclotron now in the process of construction, and then to the laboratory to view the present one and to see patients who had generously consented to present themselves for inspection and questioning. Everyone who made the trip envied the men who were so conscientiously opening up a new field for physics and medicine and everyone admired the modesty and sincerity of the staff.

The speakers and guides for the cyclotron day were Paul A. Aebersold, Ph.D., John H. Lawrence, M.D., Joseph G. Hamilton, M.D., Alfred Marshak, Ph.D., John C. Larkin, M.D., and Robert S. Stone, M.D.

The diagnostic section on Wednesday afternoon was devoted to a symposium on the lesser circulation, participated in by Dr. Fred Angle, Kansas City, Kansas, Dr. William J. Kerr, San Francisco, and Dr. Wendell G. Scott, St. Louis.

Thursday morning offered a symposium on diseases of the retroperitoneum, another panel discussion, with Dr. F. C. Helwig and Dr. Rex L. Diveley of Kansas City, Missouri, Dr. T. Leon Howard, Denver, Dr. Benjamin H. Orndoff, Chicago, Dr. Dabney Kerr, Iowa City, Dr. T. D. Cunningham, Denver, and Dr. Frank Hinman, San Francisco. This symposium had been arranged by Dr. Lewis G. Allen, Kansas City, Kansas.

The Thursday afternoon sections were exceptional because there were no symposia. An array of excellent papers was presented which deserve outline

President Wasson presents the Society's Gold Medal to Dr. Edith H. Quimby in recognition of her work on dosage and filtration.

but must be omitted here because it is impossible to mention them all. Of special interest, because of its basic character, was the paper by T. C. Evans, J. C. Slaughter, E. P. Little, and G. Failla on "The Influence of the Medium on the Radiosensitivity of Sperm."

To Thursday's program the Twenty-seventh Annual Banquet of the Society, presided over by President W. Walter Wasson, came as a fitting climax. For those whose good fortune it was to be present there is little need of any written account of what must long remain with them as a happy memory. For others words are inadequate to convey the spirit of this occasion. From a background of light and color, flowers, music, and general gayety two or three impressions stand out with special clarity: Dr. Hill's unexpected and unexcelled talents as Master of Ceremonies, Dr. Wasson's inspiring address on "The Beginnings of Disease," the presentation to Dr. Menville of the Pfahler gavel as he assumed the office of president, and the award to Dr. Edith H. Quimby of the Gold Medal of the Radiological Society of North America. Dr. Wasson's address will appear in an early issue of RADIOLOGY. Dr. Menville receives editorial tribute elsewhere in this issue. Dr. Quimby's accomplishments in the field of research are well known. Her work, more especially in the simplification of the problems of dosage and filtration, has placed every radiologist in her debt. This award is a well deserved tribute, expressive of the high regard in which she is held both professionally and personally.

The symposium and panel discussion on bone tumors on Friday morning, arranged by Dr. David S. Beilin, Chicago, and participated in by Dr. Kenneth S. Davis, Los Angeles, Dr. Keene O. Haldeman, San Francisco, and Dr. J. Vernon Luck, Los Angeles, called attention again to the fundamental lack of unity existing among pathologists and radiologists regarding bone tumors. While no definite conclusions were reached, the discussion was valuable for its clarification and emphasis of many facts regarding these diseases.

The papers which were presented Friday after-

Doctor Quimby responds to the presentation of the Gold Medal.

noon were enjoyed by an unusually large audience, a tribute to the quality of the speakers. Of special interest were the papers by Dr. Edith H. Quimby on "Practical Considerations Regarding the Employment of Various Qualities of Roentgen Rays in Therapy," and by Dr. Mayo H. Soley and Dr. Robert S. Stone on "The X-Ray Treatment of Hyperthyroidism." Drs. Soley and Stone in a carefully controlled series demonstrated the definite usefulness of irradiation in properly selected cases. The criteria used in selection and follow-up were so rigid that all prejudice in evaluating the results was eliminated. Dr. Quimby presented graphs showing surface and depth doses for various qualities of radiation which will be of great value to the roentgen therapist in selecting the most suitable quality for a particular situation.

The whole meeting was an outstanding success, from the standpoint of a good scientific program, delightful entertainment, and pleasant sociability. The meetings started on time. There was never a dull moment. Everything was done without apparent effort, which is the surest indication of thoughtful preparation and hard work on the part of Dr. Wasson and his helpers, to whom all credit is due and to whom we herewith deliver our heartiest thanks.

Surely he who travels far learns much.

SYDNEY J. HAWLEY, M.D.

THE REFRESHER COURSES

The Fourth Annual Refresher Series again constituted one of the most important scientific parts of the annual meeting of the Radiological Society of North America. The sessions were well attended and the pre-convention enrollment was surpassed by the actual attendance. Dr. Ira H. Lockwood, the able chairman, deserves great credit for his untiring efforts, which resulted in a smoothly operating, well organized schedule. Most of the assigned rooms were filled to capacity, attesting to the popularity of the forty educational courses which covered a great variety of radiologic subjects.

Although it is impossible to give a detailed description of each course, a few remarks about the series as a whole may not be amiss.

An innovation in the Refresher Series this year was the introduction of panel discussions on Radiation Therapy subjects, such as Carcinoma of the Skin, Breast, Mouth, and Uterus. These were definitely worthwhile and the plan should be continued.

Some of the speakers distributed mimeographed notes or outlines, which also served as good reviews after the sessions were over.

The first course, on Diseases of the Stomach and Duodenum, was presented by a clinical team from the Stanford University School of Medicine and medical, surgical, gastroscopic, and roentgenologic aspects were thoroughly reviewed. A similar two-day consecutive course was given by a group from the University of Pennsylvania on Roentgenology of the Urinary Tract and was especially well done. Ample opportunity for discussion from the audience was given in nearly all the courses.

Dr. R. R. Newell arranged a course on the Physics of Radiology, in which the following physicists took part: Otto Glasser, Ph.D., History of Radiology and Atomic Physics; Paul Kirkpatrick, Ph.D., Physical Properties of X-Rays; Gioacchino Failla, D.Sc., Action of X-Rays and Gamma Rays on Living Tissues.

Roentgen Analysis of Fractures was given by Dr. W. Edward Chamberlain; Acute Inflammatory Diseases of the Lung by Dr. Fred Jenner Hodges; Practical Uses of Body Section Radiography by Drs. Sherwood Moore and Wendell G. Scott; Technic in Diagnosis of Gastric and Duodenal Lesions by the Mucosal Relief Method by Dr. F. E. Templeton; Fundamentals in the Interpretation of Roentgenograms of Lungs and Pleura by Dr. D. A. Rhinehart; Roentgenologic Depiction of Intracranial Anatomy and Certain Pathologic Conditions by Dr. Kenneth D. A. Allen; Radiation Therapy of the Breast by Dr. Lewis G. Allen; Radiation Therapy of Carcinoma of the Cervix by Dr. Harold W. Jacox; Production of X-Rays by Dr. R. R. Newell, and Natural and Induced Radioactivity and the Nature of Alpha, Beta, Gamma, and Neutron Rays by Paul Aebersold, Ph.D.; Roentgen Investigation of the Esophagus by Dr. E. R. Witwer; Cardiovascular Roentgenology by Dr. Earl E. Barth; Roentgenologic Diagnosis of Intracranial Disease by Dr. John D. Camp; Differential Diagnosis of Bone Tumors by Dr. B. H. Nichols; X-Ray Therapy in Superficial Carcinoma by Dr. John T. Murphy; Irradiation Therapy of Carcinoma of the Uterine Fundus by Dr. Robert E. Fricke; Protection of Physicians, Patients, and Personnel by K. W. Stenstrom, Ph.D.; and Losing Radium and Finding It by Dr. Robert Taft; Gastro-intestinal Tract in Infants and Young Children by Dr. Samuel G. Henderson; Diseases of the Mediastinum and Associated Conditions by Dr. Lester W. Paul; Contrast Myelography by Dr. Joseph C. Bell; Radiological Aspects of the Arthritides by Dr. L. H. Garland; Practical Concepts of Diagnosis, Treatment, and Complications of Carcinoma of the Cervix by Dr. Edwin A. Merritt; Measurement, Calculations and Recording of Quality and Quantity of X-Ray Dosage by Edith H. Quimby, Sc.D.; Radiology of the Small Intestine by Dr. Kenneth S. Davis; Pulmonary Tuberculosis by Dr. C. C. Birkelo; Radiography of the Cervical Region by Dr. Charles S. Capp; Fundamental Principles of Protracted Fractional Radiation by Dr. H. Dabney Kerr; Diagnosis and Treatment of Cancer of the Skin and Lip by Dr. Henry J. Ullmann; Radiological Diagnosis of Lesions of the Colon by Dr. Lester W. Baird; Coccidioidal Granuloma by Dr. Ray A. Carter; Discussion of Anomalies and Fractures of the Spine, Including Methods of Examination by Dr. Wilbur Bailey; Reaction of the Skin to X-Rays by Drs. John C. Larkin and J. Maurice Robinson; Lymphoblastoma by Dr. A. U. Desjardins.

HAROLD W. JACOX, M.D.

THE SCIENTIFIC EXHIBITS

The Scientific Exhibits were, as usual, an outstanding feature of the meeting, and the Committee wishes to congratulate all exhibitors. The standards concerned with selection and preparation of material were unusually high. Special mention may be made of the unique method used by The Radiological Society of San Francisco.

The awards, made by the special committee appointed by the president, were as follows:

First Award, to Dr. Robert S. Stone and Dr. John C. Larkin, for their exhibit on Neutron Therapy.

Second Award, to Dr. Samuel G. Henderson and Dr. W. W. Bryant, Jr., for their exhibit on The Colon in the Healthy Newborn Infant.

Certificate of Merit, to Dr. John W. Crossan, Dr. Lowell S. Goin, and Mr. V. L. Barnard, for their demonstration of a Cassette Tunnel for Surgical Radiographic Examination of the Hip.

Honorable Mention, to Dr. Harold Brunn and Dr. Alfred Goldman, Tumors of the Lung; to Dr. Milton Friedman and Dr. John W. Hall, Histological Changes Produced by Fractionated Irradiation in Carcinoma of the Mouth and Throat; to Dr. Edward Leef and Dr. William Saunders, Gas Contrast in Colon Examinations and Some Causes for Gastro-Intestinal Bleeding.

The exhibits are briefly listed below:

Allen A. Altman, M.D., and Edward E. Fong, M.D. (San Francisco Hospital, San Francisco). Subcutaneous and Mediastinal Emphysema in Bronchial Asthma: A presentation of 3 cases with summaries of the histories and physical and roentgen findings.

Wilbur Bailey, M.D., and William S. Kiskadden, M.D. (Los Angeles). Treatment of Hemangiomata, with Special Reference to Unsatisfactory Results: An exhibit of pictures, many in color, of patients before and after various methods of treatment.

Carl D. Benninghoven, M.D., and Earl R. Miller, M.D. (San Mateo, Calif.). Coccidioides in Bone: Films and reproductions of films showing coccidioides of the bone and conditions from which it is to be differentiated.

Gerson R. Biskind, M.D., Harold Sugarman, M.D., and John J. Sampson, M.D. (Mount Zion Hospital, San Francisco). Roentgenological-Pathological Study of the Coronary Arteries: A demonstration of roentgen, pathologic, and clinical correlation, based on x-ray studies and histologic observations on autopsy specimens.

Harold Brunn, M.D., and Alfred Goldman, M.D. (University of California). Tumors of the Lung: An exhibit of 120 mounted transparencies, containing approximately 500 illustrations and charts, showing x-ray, clinical, and pathological descriptions of benign and malignant tumors of the lung with special reference to the differentiation of bronchial adenoma from carcinoma.

Lloyd Bryan, M.D., and A. J. Williams, M.D. (University of California Medical School). Roentgen Therapy in Ophthalmology: Photographs in color and statistical data.

John W. Budd, M.D., and Ian MacDonald, M.D. (Los Angeles). Analysis of 125 Cases of Cured Bone Sarcoma. An exhibit based on cured cases in the Bone Sarcoma Registry, with an improved classification. Photomicrographs and roentgenograms.

Charles S. Capp, M.D. (University of California Hospital, San Francisco). Bone Tumors: History, Roentgenograms, Treatment, Follow-up.

Charles S. Capp, M.D., and Pearl M. Smith, M.D. (Children's Hospital, San Francisco). Coincidental Roentgen Findings in Fibrocystic Disease of the Pancreas.

Charles S. Capp, M.D., and Martha Mottram, M.D. (University of California). Roentgen Demonstration of Lesions Involving the Sacrum: A roentgen film demonstration (coupled with clinical history and pathologic or autopsy reports) of lesions primarily arising in the sacrum. The response of some of these tumors to roentgen therapy was illustrated.

John W. Crossan, M.D., Lowell S. Goin, M.D., and V. L. Barnard, Techn. (Queen of Angels Hospital, Los Angeles). Cassette Tunnel for Surgical Radiographic Examination of the Hip: Demonstration of a new cassette holder, by which it is possible to obtain a true lateral projection of the neck of the femur without flexing the leg and without interference with surgical technic.

Frank S. Dolley, M.D., Lyman A. Brewer, M.D., and A. S. Churchill, M.D. (Los Angeles). Intrathoracic Tumors: Transparent reproductions in color and roentgenograms of various types of intrathoracic neoplasms.

Edward E. Fong, M.D. (San Francisco Hospital). Gaseous Cholecystitis and Cystitis: Presentation of 4 cases: 3 of cholecystitis and 1 of cystitis.

Milton Friedman, M.D., and John W. Hall, M.D. (Bellevue Hospital and New York University, New York). Histological Changes Produced by Fractionated Irradiation in Carcinoma of the Mouth and Throat: Charts and graphs demonstrating the clinical response to irradiation; photomicrographs; diagrams illustrating the mechanism of the radiation effect on the cell.

L. H. Garland, M.D., and H. A. Hill, M.D. (San Francisco). The Normal Cystic and Common Duct: An exhibit of mounted films to show the size and shape of the normal cystic and common ducts under physiological conditions of filling, and to dispel a myth concerning biliary dyskinesia.

L. H. Garland, M.D., and A. A. Altman, M.D. (Stanford University Medical School, San Francisco). Calcification of the Pancreas.

Carl L. Gillies, M.D. (University Hospital, Iowa City, Iowa). Pseudo-Gas Gangrene: Mounted film reductions and reports of cases showing roentgen evidence of interstitial gas suggesting gas gangrene but failing to show bacteria of the B. welchii group on culture.

Keene O. Haldeman, M.D., and Ralph Soto-Hall, M.D. (University of California Medical School). The Patella: Its Rôle in Injury and Disease: Anatomic specimens from man and other mammals, prehistoric and contemporary; also a series of patellae removed for traumatic and pathologic conditions, with roentgen and microscopic studies and color photographs of the operative field.

Samuel G. Henderson, M.D., and W. W. Bryant, Jr., M.D. (E. S. Magee Hospital, Pittsburgh, Pa.). The Colon in the Healthy Newborn Infant: Fluoroscopic and roentgenographic study of an unselected group of 100 infants without obvious physical defects, with follow-up studies in a number of instances.

R. W. Johnson, M.D. (Los Angeles Tumor Institute). Effects of Filtration on Soft Tissue Detail. A series of films showing improvement in soft tissue detail by use of filters in the beam.

Clifford Jones, M.D. (Kansas City, Missouri). Spondylolysis: Series of 8 × 10 films with descriptive diagrams illustrating the importance of taking films from oblique angles to demonstrate lesions before displacement has occurred.

James F. Kelly, M.D., and D. A. Dowell, M.D. (Creighton University School of Medicine, Omaha, Nebr.). The X-Ray for Prevention and Treatment of Acute Spreading Peritonitis.

Edward Leef, M.D. (Stanford University School of Medicine, San Francisco). Gas Contrast in Colon Examinations: Films showing use of air or oxygen in the colon as a double contrast with barium enema; some surgical specimens.

Edward Leef, M.D., and William Saunders, M.D. (Stanford University, San Francisco). Some Causes for Gastro-Intestinal Bleeding: X-ray films showing various lesions in the gastro-intestinal tract which cause bleeding.

Joseph Levitin, M.D. (Mount Zion Hospital, San Francisco). Differential Diagnosis of Bowel Distention: X-ray reproductions with short descriptions illustrating diagnostic features of mechanical bowel obstruction, and paralytic ileus from various causes.

Joseph Levitin, M.D., Gerson Biskind, M.D., and Helen Weyrauch, M.D. (Mount Zion Hospital, San Francisco). Roentgenologic, Pathologic Study: X-ray reproductions of interesting cases, with comparative pathologic studies.

Joseph Levitin, M.D., Allan Cohn, M.D., and Helen B. Weyrauch, M.D. (Mount Zion Hospital, San Francisco). Correlation of X-Ray and Gastroscopic Examinations: Roentgenograms, drawings and photographs in color, and plastic models.

Joseph Levitin, M.D., and Harold Brunn, M.D. (Mount Zion Hospital, San Francisco). Study of the Lobes of the Lung and Interlobar Fissures: Diagrams illustrating the appearance of the fissures and the lobes in anterior-posterior and lateral views; x-ray reproductions of typical cases.

Bernard H. Nichols, M.D. (Cleveland Clinic, Cleveland, Ohio). Thorotrast in Diagnosis of Lesions in the Lower Spinal Canal. Description of technic of thorotrast myelography, and demonstration of its value in lesions of various types.

Robert A. Powers, M.D., and Dorothy J. Starks, M.D. (Palo Alto Hospital, Palo Alto, Calif.). Acute (Primary) Coccidioidomycosis: A series of original chest films depicting the first stage lesions of coccidioidomycosis as seen in a group of students, presumably infected at the same time and place; follow-up films made one year following the primary infection.

San Francisco Radiological Society. Study Cases Presented by The San Francisco Radiological Society.

J. B. de C. M. Saunders, F.R.C.S., and Verne T. Inman, M.D., Ph.D. (University of California Medical School). Pathological Conditions and Anatomical Relationships of the Vertebral Column.

Rudolph Skarda (University of California). Demonstration of Membranous Cartilages and Ossification Centers of Fetuses—9 to 36 Weeks.

Albert Soiland, M.D. (Los Angeles Tumor Institute). Photographs Before and After Treatment.

C. A. Stevenson, M.D., and L. W. Baird, M.D. (Scott and White Clinic, Temple, Texas). Emphysematous Cholecystitis: Series of prints and charts of a case of emphysematous cholecystitis diagnosed and treated roentgenologically.

Robert S. Stone, M.D., and John C. Larkin, M.D. (University of California). Neutron Therapy: A lantern slide demonstration of treatment effects and other phases of work in the Radiation Laboratory.

Charles G. Sutherland, M.D. (Mayo Foundation, Rochester, Minn.). Reproductions of Roentgenograms for Educational Purposes: Reproductions of roentgenograms on microfilm in rolls for library purposes, with microfilm reader; demonstration of filing system and of use of individual copies as lantern slides.

A. Justin Williams, M.D., and Homer V. Hartzell, M.D. (San Francisco Hospital). Perforated Peptic Ulcer: A comparison of the value of films made with the patient in the erect position and in the left lateral decubitus position to demonstrate the presence of pneumoperitoneum in gastro-intestinal perforations.

E. R. WITWER, M.D.

THE TECHNICAL EXHIBITS

This year the light and airy Plunge Room at the Fairmont Hotel was the setting for 21 technical displays and the usual pauses that refresh. Much of the display was eye appeal and here and there it was noted that even the usually conservatively designed x-ray apparatus shared a bit in common with the streamlined motif of booth partitions and back drops. More than ever color shared in the picture with fluorescent lighting effects, iridescent back drops, and colorful and artistic photographic displays. All in all the setting added its bit to an air of good fellowship and gayety that prevailed throughout the meeting. For those who are still a bit foggy from it all and for those who were unable to attend this year, a short refresher course on the high spots of the technical exhibits seems in order.

Canadian Radium & Uranium Corporation (630 Fifth Ave., New York, N. Y.) presented a complete line of radium applicators and data concerning their use.

Davies Rose & Company, Ltd. (22 Thayer St., Boston, Mass.), whose name is synonymous with the early days of cholecystography, featured their product "Shadocol," a well known cholecystopaque that has stood the test of time.

Dupont Film Mfg. Corporation (9 Rockefeller Plaza, New York, N. Y.), where Ford and Poole shared the duties of M.C., introduced a new pull-a-tab dental x-ray film—and who didn't pull one!—a clever idea to save time and tempers. Also featured were radiographs on Dupont x-ray film and Dupont liquid chemicals which make mixing your own a pleasure.

Eastman Kodak Company's (343 State Street, Rochester, N. Y.) display was headlined by the ever genial host, Fred Martin. Color was the predominant note, from Blue Brand ultraspeed x-ray film to Kodachrome, Minicolor, and Kotavachrome prints. A haven for the photo addicts, who handled the new Ektar and Medalist cameras with envious eyes, for just try and get one if you can.

General Aniline & Film Corporation (Binghamton, N. Y.) (Agfa Ansco) utilized a novel mechanical illuminator with ever changing radiographs to show the effects on contrast produced by voltage variations with Hi-speed and non-screen films. Their beautiful radiographs of flowers added an artistic touch to the booth and provoked many comments.

General Electric Corporation (2012 Jackson Blvd., Chicago, Ill.) along with various types of equipment featured a new and smaller rotating anode tube. A prominent feature of their display was a 4 × 5" stereo fluorographic apparatus and viewing stereoscope. Demonstration films when viewed in this stereoscope revealed a quality and detail of shadows that aroused much comment.

Kelley-Koett Mfg. Company (Covington, Ky.). This was an initiation meeting for Kelley-Koett's new President, Mr. A. H. Feibel. Kelley-Koett featured their 200 and 500 M.A. vertical control that incorporates true fixed milliamperage and the Multicron with single push-button control. Also shown was a 15 M.A. 80 P.K.V. portable and a W-2 tilt table and tube stand.

Liebel-Flarsheim Company (303 W. Third St., Cincinnati, O.), in addition to their standard line of diagnostic and therapy timers, Buckys and grids, featured a portable "Bovie" electric surgical unit.

Machlett Laboratories, Inc. (Springdale, Conn.) centered their display around a cut-away model of their new Type Dynamax rotating tube and its individual units. Also shown by cut-away models were a new rapid cooling 100 P.K.V. shockproof radiographic-superficial therapy tube and a water-cooled 140 P.K.V. Thermax radiographic-intermediate therapy tube.

F. Mattern Mfg. Company (4647 N. Cicero Ave., Chicago, Ill.) featured a new motor drive 4-valve unit incorporating a motor driven timer having an automatic cut-out to eliminate over-exposure and tube damage with fixed milliamperage technic and the appropriate focal spot.

The Medical Bureau (Palmolive Bldg., Chicago, Ill.), through its booth depicting a pine-panelled New England fireside, emanated a feeling of real hospitality made genuine by the presence of its director, Bernice Larson. The services of the Bureau for those seeking an associate or change of location are well known.

C. V. Mosby Company (3925 Pine Blvd., St. Louis, Mo.) had on display their usual comprehensive collection of medical books and particularly featured those of interest to the radiologist. A real opportunity to thumb through the favorites and inspect the newcomers.

The Patterson Screen Company (625 Main St., Towanda, Pa.): A rendezvous with our old friends, Patt and Patterson screens, both an inseparable part of radiology and radiologic meetings. We missed Art Reuter's friendly smile.

Philips Metalix Corporation (419 Fourth Ave., New York, N. Y.) displayed their Chaoul type contact therapy apparatus, a Rotalix heavy anode tube featuring a ribbon wound tungsten anode face, and the Photalix. Because of its construction the Photalix tube retains the inherent properties of oil insulation without the increase of inherent filtration usual with oil immersion.

Picker X-Ray Corporation (300 Fourth Ave., New York, N. Y.) showed a complete line of representative diagnostic and therapeutic equipment including a field model portable for Army use. Featured on the tilt table was a modified spot film device designed to permit 4, 2, or 1 exposures on an 8 × 10" film.

Radium Chemical Company, Inc., (570 Lexing-

ton Ave., New York, N. Y.) presented their comprehensive line of radium applicators and data for their use.

J. W. Stacey, Inc. (236 Flood Bldg., San Francisco, Calif.) presented an interesting display of medical books and books on medical history. Here was an opportunity to thumb through a proof copy of Clapesattle's *The Doctors Mayo*, which has since been published

Standard X-Ray Company (1932–42 N. Burling St., Chicago, Ill.), in addition to its usual line of x-ray apparatus, featured a new medium for oral cholecystography, "Cystopaque," which is available in three potencies, light, medium, and heavy.

Westinghouse Electric & Mfg. Company (Long Island City, N. Y.) featured the X-actron, an automatic electronic filament control operated by the milliamperage flowing through the tube, thereby eliminating the conventional filament control from the control panel. Considerable interest was aroused by a new 8 × 10″ four-on-one spot film serialograph incorporating a 14 × 14″ fluoroscopic screen.

National Synthetics (270 Lafayette St., New York, N. Y.), best known for T.I.P.P.S., a gall-bladder dye in chocolate or mint flavored powders, featured their new product, "Cholex," a lecithin-egg yolk and glycerine combination to be used as a fat meal in cholecystography.

Specialty Engineering Company (801 W. Washington Blvd., Los Angeles, Calif.) featured the Simplex x-ray film marker, a practical and simple photo reduction method of incorporating identifying data on a radiograph. In addition, a small complete unit for radiographic-fluoroscopic work in the practitioner's office was shown.

JOHN D. CAMP, M.D.

APPLICATION FOR CERTIFICATES

At a special meeting of the Board of Trustees of The American Board of Radiology, Article VIII of the By-laws of the Board was amended to read as follows:

ARTICLE VIII

Applicants for Certificates

Section 1. Method of Making Application. Applications for certificates shall be made to the Secretary upon a prescribed form. Each application shall be accompanied by a fee in such sum as the Board, from time to time, may fix. The application shall also be accompanied by an unmounted photograph of the applicant.

Section 2. Qualifications of Applicants. Each applicant for admission to the examination shall be required to present evidence that he has met the following standards:

(A) General Qualifications.
  (1) Satisfactory moral and ethical standing in the profession.
  (2) A license to practise medicine in the state or county in which he resides.
  (3) Membership in The American Medical Association, or membership in such Canadian or other medical societies as are recognized for this purpose by the Council on Medical Education and Hospitals of The American Medical Association.* Except as herein provided, membership in other societies shall not be required.
  (4) That the applicant holds himself out to be a specialist in Radiology or one of its branches as defined under "Definitions," and that he devotes his time primarily and principally (at least 75 per cent) to the practice of Radiology or one of its branches.
  (5) That he is a citizen of the United States or Canada.** Candidates from other countries must be permanent residents of that country and native citizens thereof.**

(B) General Professional Education.*
  (1) Graduation from a medical school recognized by the Council on Medical Education and Hospitals of The American Medical Association. If the applicant is a resident of the United States or one of its possessions and is a graduate of a medical school outside the United States or Canada he must have a certificate of The National Board of Medical Examiners.
  (2) Completion of an internship, preferably of the general rotating type, of not less than one year in a hospital approved by the same Council.

(C) Special Training.* (Applicable to candidates who begin their training on or after January 1, 1942, and to all candidates who are to be examined after January 1, 1945.)
  (1) After the completion of the internship there shall be a period of special training in Radiology of not less than three years in clinics, hospitals or dispensaries recognized and approved by The American Board of Radiology and the Council on Medical Education and Hospitals of The American Medical Association as competent to provide a satisfactory training in Radiology. This period of specialized training shall include:
    (a) Graduate training in pathology, radiation physics, and radiobiology.

      A period of six months full-time training in pathologic anatomy is recommended but where this is not possible to arrange, the student, during his three-year training period may, by attending pathologic conferences, postmortem examinations, and studying removed tissues, receive adequate training in pathology. It is recommended that radiation physics be taught by a combination of didactic lectures, practical examples, and direct clinical demonstrations.

    (b) An active experience (residency) of not less than twenty-four months in an institution, the radiologic department of which is recognized and approved by The American Board of Radiology and the Council on Medical Education and Hospitals of The American Medical Association as capable of providing satisfactory training.

      By special permission of the Board all or part of this training may be obtained under the immediate preceptorship of a radiologist or group of radiologists recognized by The American Board of Radiology as offering appropriate facilities for this type of postgraduate experience. Or the Board will accept a combination of training as outlined in (a) and (b)—for example, one

* Note: In special instances and by unanimous consent of the Credentials Committee of the Board, these requirements may be modified.

** Note: In special instances and by unanimous consent of the Trustees of the Board, these requirements may be modified.

may take a graduate course, including the basic sciences, in an accredited graduate school for one year, a residency for one year, and a preceptorship for one year; or he may take a graduate course for one year plus either a residency or preceptorship for two years.

(c) Examination in the basic sciences of Radiology as well as the clinical aspects thereof.

These examinations should be given by the student's instructors in order to allow those responsible for his training to certify to the Board that he is adequately prepared.

CERTIFICATES GRANTED

The following is a list of those who have been certified or granted additional certification during 1941. An asterisk (*) indicates additional certification.

1. Anderson, Charles Watson, Camp Polk, La., *Radiology*
2. Anderson, Johnson Rose, Shreveport, La., *Roentgenology*
3. Anthony, Benjamin W., Chicago, Ill., *Radiology*
4. *Ashbury, Howard Hicks, Baltimore, Md., *Radiology*
5. Attwood, Cyril John, Oakland, Calif., *Radiology*
6. Baender, Eric, Freeport, L. I., N. Y., *Radiology*
7. Baeyer, Eric Von, Cleveland, Ohio, *Roentgenology*
8. Baker, Sol Ronald, Los Angeles, Calif., *Therapeutic Radiology*
9. Beck, John, New York, N. Y., *Radiology*
10. Benzing, George, Jr., Cincinnati, Ohio, *Diagnostic Roentgenology*
11. Bierman, Morris I., Washington, D. C., *Diagnostic Roentgenology*
12. Bouchard, Jean, Montreal, Quebec, Canada, *Radiology*
13. Boyd, Robert Wallace, Calgary, Alberta, Canada, *Radiology*
14. Boyer, Richard C., Chicago, Ill. (now at Fort Bliss, Texas), *Radiology*
15. Brackin, John T., Jr., Youngstown, Ohio, *Radiology*
16. Breimer, Charles, W., New York, N. Y., *Diagnostic Roentgenology*
17. Bristow, Louis Judson, Jr., New Orleans, La., *Radiology*
18. Brock, Ernest H., New Orleans, La., *Diagnostic Roentgenology*
19. Brogan, Austin John, Dayton, Ohio, *Diagnostic Roentgenology*
20. Brown, Walter Earl, Schenectady, N. Y., *Radiology*
21. Bruder, Victor F. J., Winona, Minn., *Radiology*
22. Bunce, James Walter, North Adams, Mass., *Diagnostic Roentgenology*
23. Buschke, Franz J., Seattle, Wash., *Radiology*
24. Buzaid, Louis L., Honolulu, T. H., *Radiology*
25. Campbell, John Alexander, Cincinnati, Ohio, *Radiology*
26. Campbell, Thomas Anthes, Philadelphia, Pa. (now at Fort Eustis, Va.), *Radiology*
27. Carrigan, Francis P., Newark, N. J., *Roentgenology*
28. Cawley, Frank Thomas, Washington, D. C., *Radiology*
29. Chalek, Jack I., Johnson City, N. Y., *Radiology*
30. Childs, Theron Baker, Evanston, Ill., *Roentgenology*
31. Clift, Myron William, Flint, Mich., *Radiology*
32. Cobbs, Lea A., Salem, Ohio, *Roentgenology*
33. Cohn, Harold Arnold, Vancouver, Wash., *Radiology*
34. Cooper, Wayne K., Iowa City, Iowa (now at Jefferson Barracks, Mo.), *Radiology*
35. Cosgrove, William James, Grand Rapids, Mich., *Radiology*
36. Cove, Arthur M., Fort Totten, N. Y., *Radiology*
37. Cowan, Leland R., Salt Lake City, Utah, *Therapeutic Radiology*
38. Crowder, Robert M., Albany, N. Y., *Radiology*
39. Culver, Gordon J., Buffalo, N. Y., *Roentgenology*
40. Dillman, Melvin A., Philadelphia, Pa., *Radiology*
41. Dougall, John Mac, Memphis, Tenn., *Roentgenology*
42. Duff, Alexander McGill, Jr., Philadelphia, Pa., *Therapeutic Radiology*
43. Eaglesham, Douglas Cameron, Montreal, Quebec, Canada (now at No. 1 Neurological Hospital, Canadian Army Overseas), *Roentgenology*
44. Elkin, William Paul, Charleston, W. Va., *Radiology*
45. Faris, Hervey S., Tucson, Ariz., *Roentgenology*
46. Fetter, John S., Philadelphia, Pa., *Radiology*
47. Fleischner, Felix, Greenfield, Mass., *Radiology*
48. Foster, Frank Lloyd, Cranford, N. J., *Diagnostic Roentgenology*
49. Fox, Isar, Harlingen, Texas, *Diagnostic Roentgenology*
50. Francis, William Joseph, New York, N. Y., *Diagnostic Roentgenology*
51. Freedman, Lester M. Jules, Pittsburgh, Pa., *Radiology*
52. Friedell, Hymer L., New York, N. Y., *Radiology*

53. Frost, Earl J., Wichita, Kan., *Diagnostic Roentgenology*
54. Fullenlove, Thomas McLellan, San Francisco, Calif., *Radiology*
55. Ghiselin, Francis H., New York, N. Y., *Diagnostic Roentgenology*
56. Glickman, L. Grant, Minneapolis, Minn., *Diagnostic Roentgenology*
57. Godfrey, Ellwood Watson, Philadelphia, Pa., *Radiology*
58. Goehring, Harrison D., Boston, Mass., *Roentgenology*
59. Goss, Erich, Woodside, L. I., N. Y., *Diagnostic Roentgenology*
60. Greenidge, Robert, Detroit, Mich., *Diagnostic Roentgenology*
61. Grossman, Jack William, Chicago, Ill., *Radiology*
62. Hamilton, John Bland, Kingsport, Tenn., *Roentgenology*
63. Harvey, Rolfe Marsh, Bryn Mawr, Pa., *Radiology*
64. Haworth, James Blaine, Portland, Ore., *Radiology*
65. Heilbrun, Norman, Buffalo, N. Y., *Roentgenology*
66. *Held, Louis Arthur, Brooklyn, N. Y., *Radiology*
67. Hemminger, George W., Sacramento, Calif., *Roentgenology*
68. Hewes, Frederic Leo, Cleveland, Ohio, *Radiology*
69. Hiemstra, Wybren, Minneapolis, Minn., *Radiology*
70. Holleb, Eugene Milton, New York, N. Y. (now at Pine Camp, N. Y.), *Radiology*
71. Horwitz, Manuel, Providence, R. I., *Radiology*
72. Hsü, Chien-Liang, Peiping, China, *Radiology*
73. Huffman, John Francis, San Francisco, Calif., *Roentgenology*
74. Hughes, Charles Robert, Cleveland, Ohio, *Roentgenology*
75. Hurt, Floyd Kinzer, Lakeland, Fla., *Roentgenology*
76. Imboden, Henry Miles, Mt. Vernon, N. Y., *Radiology*
77. Imler, Allison Ellwood, Philadelphia, Pa., *Therapeutic Radiology*
78. Jacobs, Melville Leonard, Pasadena, Calif., *Therapeutic Radiology*
79. Kaighn, Charles B., Atlantic City, N. J., *Roentgenology*
80. Kibbe, Pressley A., New Orleans, La., *Radiology*
81. Klinefelter, Edmund William, York, Pa., *Diagnostic Roentgenology*
82. Kolker, Louis, New York, N. Y., *Radiology*
83. Kornblum, Daniel, Jackson Heights, L. I., N. Y., *Radiology*
84. Larson, Sidney, Rochester, N. Y., *Radiology*
85. Levi, Sam, New Orleans, La., *Roentgenology*
86. Levy, Jack Heymann, New York, N. Y., *Radiology*
87. Lipschutz, Isidore S., New York, N. Y., *Radiology*
88. Little, Edgar Hugh, New Orleans, La., *Radiology*
89. Long, Leonard, Bluffton, Ind., *Radiology*
90. McAneny, John Barry, Johnstown, Pa., *Radiology*
91. McCullough, John A., Rochester, Minn., *Radiology*
92. McDonald, Eugene Joseph, Boston, Mass. (now on *U. S. S. West Point*), *Radiology*
93. McDowell, John R., Lakewood, Ohio, *Diagnostic Roentgenology*
94. Marcovich, A. W., Paw Paw, Mich., *Radiology*
95. Mendel, Walter H., Haverstraw, N. Y., *Diagnostic Roentgenology*
96. Mershon, Harry F., Los Angeles, Calif., *Therapeutic Radiology*
97. Miller, Edith Irene, Petersburg, Va., *Radiology*
98. Miller, Ivan J., San Francisco, Calif., *Radiology*
99. Miller, S. Thomas, Philadelphia, Pa., *Radiology*
100. Moorehead, Matthew Talmadge, Endicott, N. Y., *Radiology*
101. Morton, Joseph L., Cleveland, Ohio, *Radiology*
102. Mueller, Hans Peter, Boston, Mass., *Radiology*
103. *Mueller, Wilbur Kenneth, St. Louis, Mo., *Radiology*
104. Nash, Leo A., Fargo, N. D., *Radiology*
105. Nitkin, Robert Lewis, Jamaica, L. I., N. Y., *Radiology*
106. Nolan, Charles Joseph, St. Louis, Mo., *Radiology*
107. Palmer, Marta S., Manteno, Ill., *Diagnostic Roentgenology*
108. Parsons, Philip Brower, Charlotte, N. C., *Radiology*
109. Pascucci, Lucien Michele, Springfield, Mo., *Radiology*
110. *Pettit, Roswell T., Ottawa, Ill., *Radiology*
111. Pickwick, Erskine R., Fitchburg, Mass., *Radiology*
112. Poplack, Samuel Lewis, Taunton, Mass., *Diagnostic Roentgenology*
113. Prentice, Donald D., Albany, N. Y., *Diagnostic Roentgenology*
114. Prickett, John A., Abington, Pa., *Radiology*
115. Pugh, David G., Rochester, Minn., *Radiology*
116. Quinn, William P., New York, N. Y., *Radiology*
117. Reavis, Charles William, Kinston, N. C., *Radiology*
118. Reingold, Morris, Quantico, Va., *Diagnostic Roentgenology*
119. Rivkin, Hyman, Far Rockaway, N. Y., *Diagnostic Roentgenology*

120. Ruby, Robert J., Waterbury, Conn., *Radiology*
121. Rudner, Nathan, Charleston, S. C., *Radiology*
122. Russell, Thomas G., St. Louis, Mo., *Radiology*
123. Saul, Walter, Orange, Calif., *Roentgenology*
124. Scarpellino, Louis, Kansas City, Mo., *Radiology*
125. Scatchard, G. Newton, Buffalo, N. Y., *Roentgenology*
126. Schmidt, Hilmar Reinhold, Petersburg, Va., *Therapeutic Radiology*
127. Schneider, Martin, Dallas, Texas, *Radiology*
128. Sell, Frederick William, Rahway, N. J., *Diagnostic Roentgenology*
129. Seltz, Herman, Mitchel Field, L. I., N. Y., *Radiology*
130. Settle, John William, Jr., Baltimore, Md., *Radiology*
131. Shehadi, William Henry, Hanover, N. H., *Radiology*
132. Shelden, James Thomas, Rochester, Minn., *Radiology*
133. Sherman, Benjamin H., Hollywood, Calif., *Therapeutic Radiology*
134. Shinney, Arthur Paul, Everett, Mass., *Diagnostic Roentgenology*
135. Shull, Elliott C., Camden, N. J., *Roentgenology*
136. Silverman, Morris, Washington, D. C., *Radiology*
137. Silveus, Esther, Pittsburgh, Pa., *Roentgenology*
138. Singer, John Edward, Akron, Ohio, *Radiology*
139. Singer, Siegmund F., New Hampton, Iowa, *Roentgenology*
140. Siwinski, Arthur G., Baltimore, Md., *Therapeutic Radiology*
141. Slasor, William Johnson, Ann Arbor, Mich., *Radiology*
142. Slater, Max, Jackson Heights, L. I., N. Y., *Roentgenology*
143. Slobodin, Harry, Hines, Ill., *Therapeutic Radiology*
144. Sorrell, Lewis Edmond, Birmingham, Ala., *Roentgenology*
145. Stillwell, Harry C., Rahway, N. J., *Diagnostic Roentgenology*
146. Stork, Walter J., Houston, Texas, *Radiology*
147. Strax, Philip, New York, N. Y., *Radiology*
148. Sturr, Robert P., Philadelphia, Pa., *Diagnostic Roentgenology*
149. Tager, Stephen Nathaniel, New Rochelle, N. Y., *Roentgenology*
150. Tharp, George W., Knoxville, Tenn., *Radiology*
151. Thompson, Archibald W., Buffalo, N. Y., *Diagnostic Roentgenology*
152. Trask, Burton Warren, Camp Edwards, Falmouth, Mass., *Diagnostic Roentgenology*
153. Tucker, Dan, New York, N. Y., *Roentgenology*
154. Van Zwaluwenburg, Benjamin Reyer, Toledo, Ohio, *Radiology*
155. Vaughan, Charles Edward, Hamilton, Ontario, Canada, *Radiology*
156. Walker, Dora V. H., Great Falls, Mont., *Roentgenology*
157. Ward, Willis Alfred, Chicago, Ill., *Diagnostic Roentgenology*
158. Watterson, Kenneth Ward, Meadville, Pa., *Radiology*
159. Weber, Joseph G. S., Indianapolis, Ind., *Radiology*
160. Weir, Don C., St. Louis, Mo., *Radiology*
161. Weisman, Joseph Charles, South Ozone Park, N. Y., *Diagnostic Roentgenology*
162. Wessel, I. J., Philadelphia, Pa., *Diagnostic Roentgenology*
163. Wexler, Harry, Philadelphia, Pa., *Diagnostic Roentgenology*
164. Weyrauch, Helen B. S., San Francisco, Calif., *Radiology*
165. White, George, Wrentham, Mass., *Radiology*
166. Whiteleather, John E., Memphis, Tenn., *Roentgenology*
167. Wiklund, Folke Walfred, Boston, Mass., *Roentgenology*
168. Witten, Morris, Brooklyn, N. Y., *Radiology*
169. Woods, Harold Harrison, Topeka, Kan., *Radiology*
170. Yoelson, Irwin E., Cleveland, Ohio, *Roentgenology*
171. Young, Asa Dougal, Baltimore, Md., *Radiology*

ANNOUNCEMENTS AND BOOK REVIEWS

Eastern Conference of Radiologists

January 23–24, 1942

The following program has been arranged for the Eastern Conference of Radiologists, meeting in New York on January 23–24.

Registration fee of $5.00 includes luncheon and banquet tickets.

January 23

DIAGNOSTIC SECTION, 9 A.M.
Ross Golden, M.D., Chairman

1. Roentgenography of Exophthalmos, RAYMOND PFEIFFER, M.D.
2. Biochemical Aids to Roentgenological Problems in the Differential Diagnosis of Bone Disease, ALEXANDER B. GUTMAN, M.D.
3. Toxoplasmosis in Infancy, ABNER WOLF, M.D., DAVID COWAN, M.D., and CORNELIUS G. DYKE, M.D.
4. Neurofibromatosis of Bone, MURRAY M. FRIEDMAN, M.D.

THERAPY SECTION, 10:45 A.M.
Maurice Lenz, M.D., Chairman

1. Radiotherapy of Tumors of the Brain, CORNELIUS G. DYKE, M.D., and LEO M. DAVIDOFF, M.D., with Discussion by JOHN R. CARTY, M.D.
2. Roentgen Therapy of Keloids, ARTHUR HUNTER, M.D., with Discussion by JEROME P. WEBSTER, M.D.
3. Roentgen Therapy of Tuberculosis of Lymph Nodes, by MAURICE LENZ, M.D., HAIG KASABACH, M.D., and WILLIAM CHANG, M.D., with Discussion by JOHN HANFORD, M.D.
4. Lymphosarcoma in Children, by WILLIAM HOWES, M.D., with Discussion by SAMUEL RICHMAN, M.D.

DIAGNOSTIC SECTION, 2:15 P.M.
Ramsay Spillman, M.D., Chairman

1. Post-Traumatic Necrosis of Bone, RAYMOND W. LEWIS, M.D.
2. Osteoid Osteoma, MAURICE M. POMERANZ, M.D.
3. Incidence of Caisson Disease in Compressed-Air Workers, A. L. L. BELL, M.D., GEORGE EDSON, M.D., and N. HORNICK, M.D.
4. Radiology in Army Recruits, DAVID EHRLICH, M.D.
5. X-Ray Observations During the Treatment of Club Feet, JOHN P. STUMP, M.D.

THERAPY SECTION, 3:30 P.M.
William Harris, M.D., Chairman

Symposium on Radiation Injuries in the Treatment of Cancer of the Cervix, WILLIAM HARRIS, M.D., SIDNEY M. SILVERSTONE, M.D., and C. B. BRAESTRUP

Discussion, EDITH QUIMBY, M.S., Sc.D., JAMES A. CORSCADEN, M.D., NELSON B. SACKETT, M.D., IRA I. KAPLAN, M.D., and WILLIAM P. HEALY, M.D.

BANQUET, 7:15 P.M.

January 24

DIAGNOSTIC SECTION, 9:00 A.M.
Marcy Sussman, M.D., Chairman

1. Ulcerative Colitis: (1) Indications for Surgical Treatment, MOORE A. MILLS, M.D.; (2) Roentgenological Findings Before and After Surgical Treatment, WILLIAM H. BOONE, M.D.
2. Diffuse Jejuno-Ileitis, MARCY SUSSMAN, M.D., and EMANUEL WACHTEL, M.D.
3. Circumscribed Mediastinal Neoplasms, HAROLD NEUHOF, M.D.
4. Renal Osteitis, MAXWELL H. POPPEL, M.D.

THERAPY SECTION, 10:45 A.M.
Douglas Quick, M.D., Chairman

1. Radioactive Phosphorus as a Therapeutic Agent in Malignant Neoplastic Disease, JOHN M. KENNEY, M.D., with Discussion by LLOYD F. CRAVER, M.D.
2. Recent Studies in the Production of Cancer by Chemical Compounds, CORNELIUS P. RHOADS, M.D.

Letters to the Editor

BRITISH RADIOLOGY AND THE WAR

31. August, 1941

Dear Dr. Howard P. Doub

We should like you to know how much we appreciate, now even more than in normal times, the continued arrival of RADIOLOGY month by month. Your April issue with its articles on Naval and Military aspects of radiology has its own special appeal, and Dr. Edward C. Ernst is to be congratulated on "Reminiscences of Roentgenology in the Last War," for both the text and the illustrations vividly recall the working conditions of that time, and remind us of the excellent results obtained with com-

paratively primitive appliances by workers who to many of us here are not mere names, but colleagues remembered with affectionate admiration.

As nearly a year has passed since the discussion on War Radiology published in the above-mentioned issue, certain quotations therein from letters of Dr. A. E. Barclay fall themselves into the category of "Reminiscences," for things have changed since the late Autumn of 1939. Had the heavens then fallen—as there appeared to be every reason to expect—upon London and the industrial centres, they would have fallen upon considerably evacuated areas, with hospitals virtually emptied in order to provide accommodation for the casualties which had been anticipated. We must always be thankful that our early anxieties did not materialise.

Pre-war forethought and organisation had produced schemes whereby the permanent general and special institutions, supplemented by improvised hospitals, would provide the necessary facilities, with reservations for the normal flow of Medical and Surgical emergencies. Some of the larger X-ray installations were evacuated from vulnerable zones and replaced by simpler apparatus, which was also available in widespread new units, and this proved capable of dealing with all but the more highly specialised types of investigation. Thus hospitals and medical services were evolved and developed in the less vulnerable areas outside the big centres, but within a very short time city hospital practice was being resumed in most institutions, and even during and after the heavy air-raids of September and October 1940, the routine clinical and departmental activities continued.

Many hospitals have been more or less severely damaged, and some irreparably so, but their work continues there or elsewhere, and so in most institutions there is but small decrease in the X-ray departmental service or alteration in the nature of the routine work undertaken as compared with peacetime. The radiology of air-raid casualties is very varied and much of it is simple in the initial stages, just as it is in forward areas in the field, but when necessity calls (as it often does) for the closest cooperation between surgeons and radiologists, it is available as it was in more peaceful days. You will realize that we were rather perturbed at the thought that allusions to essential stringencies of a preparatory phase in 1939 might have conveyed to our American colleagues the erroneous impression that radiological activities in the great cities are more or less at a standstill.

The evacuation of so many of the older folk from the cities has necessitated the development of Radiation Therapy Centres in less vulnerable areas, including the provision of facilities for the use of radium, but many city hospital X-ray therapy departments are still active, caring for such as can be treated as out-patients and as far as beds permit for in-patients.

This is how we find ourselves to-day, and your readers may be interested to know in a general way the readjustments that time and experience have brought about.

With the kindest thoughts from the British Institute of Radiology to our colleagues in the United States of America.

Yours sincerely,
D. B. McGRIGOR

32, Welbeck St.,
London, W. 1

EDITOR'S NOTE: Colonel McGrigor, as many of our readers will recall, is President of the British Institute of Radiology. RADIOLOGY is happy to publish his letter, bringing greetings from our British colleagues.

SUED FOR MALPRACTICE EIGHTEEN YEARS AFTER RENDITION OF MEDICAL SERVICES

Dec. 20, 1940.

To the Editor

Dear Sir:

In the April 1935, issue of RADIOLOGY (**24:** 500, 1935) I reported a lawsuit for malpractice based upon services rendered sixteen years before. At that time I thought this was a record but, as some one has said, "records are made to be broken." The following case is a record breaker.

In March 1919, a mother took her 15-months-old daughter to a physician for treatment for an angiomatous nevus on the face. The last treatment was administered in May 1919, and the physician's records indicate that he has not seen the patient since that time. His records of the treatment are, of course, not all that they should be.

The patient, now a young woman, has a facial defect and alleges that she has been told by several physicians that "it is too bad that the doctor did not know more about the use of radium." She further alleges that the defect hinders her in the musical stage career for which she has been prepared and educated. And she is suing for a pretty sum.

What chance, if any, has the physician to defend this case successfully? His records made in 1919 are fragmentary and incomplete at best; while the allegations of the plaintiff's attorneys will be sharply delineated, crisp, cutting, commatic, and concise. They will contain all the descriptive adjectives shrewd attorneys can find in the dictionaries and they will describe the suffering of the plaintiff in terms so heart rending that the corner stone of Malebolge will be heated almost to the melting point. Amenti, Naraka, and Tophet will be described; the pleader will weep, and the jury will decide that the doctor must pay.

The important question is, *what can we do about it?*

I. S. TROSTLER

Book Review

HISTOLOGIC STUDIES ON THE NORMAL AND THE IRRADIATED SUPRARENAL GLAND IN RABBITS (Contribution to the Subject of Seasonal Changes in the Adrenal Cortex and of the Differentiation of the Cortex Cells). By OLAV TORGERSEN. A monograph containing 112 pages with 12 tables and 7 plates. Published by Jacob Dybwad, Oslo, Norway, 1940. Price not stated.

Following a brief review of the general literature concerning the adrenal glands, the author covers in more detail clinical and experimental investigations dealing with the effect of x-rays upon the adrenals of both man and animals. He concludes that clinical estimates of adrenal cortical degeneration as a result of irradiation by x-rays are difficult to evaluate and furthermore that they give no good evidence that the cortex is especially radiosensitive. Concerning his own investigations, carried out entirely on rabbits, he first discusses all of the possible sources of error and then examines in great detail large numbers of normal glands, including their numerous "normal variations." He properly points out that female animals must be totally disqualified because degeneration of the ovaries, which, due to their anatomical position, cannot be excluded from the field of radiation, would cause secondary effects in the adrenals.

To his experimental rabbits the author gave single massive doses of x-ray (3,000 to 5,000 r) directed to the adrenals alone and to the adrenals and surrounding viscera. Thus, he was able to study the effects of irradiation upon the adrenals, both directly and secondary to changes in other organs. He found that, except for focal areas of necrosis and scattered cellular changes in the cortex of a few animals, there were no significant changes which might indicate either degeneration or stimulation of the adrenal cortex or medulla. Furthermore, the concurrent inflammatory skin changes and the ulcers produced in the stomach and colon caused no secondary effects in the adrenals. Conversely, direct irradiation of the adrenal glands alone had no secondary effect upon the thyroid, pituitary, or mature testis. It was found, however, that when young animals were used, the rate of maturation of the testis was temporarily delayed.

In his discussion Torgersen notes that his observations are in complete disagreement with those of many previous investigators who claimed marked radiosensitivity of the adrenal glands. Their conclusions he believes are due to misinterpretation of the microscopic findings, normal variations, and postmortem changes. All in all, the author's investigation was quite thorough and performed with painstaking observance of detail, and therefore should be considered as added proof of the radioresistance of the adrenal glands.

Inclusive Hospital Rates: An Analysis

When John Jones enters a hospital on the advice of his family doctor, he would like a definite idea of what his hospital bill is going to be. He may select a room at a predetermined daily cost according to his tastes and pecuniary status, but no one can tell him how long he will be in the hospital or how many extra charges he will incur before he is discharged. To provide an answer to one or both of these questions, some rather ingenious proposals have been advanced by a number of hospital executives writing in hospital publications during recent years.[1]

An "inclusive" or "flat" rate has been advocated, with enthusiastic claims for its advantages. The basic principle has as many modifications as there are plans in operation. In essence, it amounts to a limited application of the insurance principle. Insurance spreads the cost of a probable or contingent loss over a period of time and over a group of risks. Group hospitalization employs both these factors under plans providing for prepayment by subscribers to cover the cost of future hospitalization by members of the group. Inclusive rates spread the cost of probable expenses over a group, *i.e.*, all patients hospitalized in the institution. It does not spread the cost over a period of time because no payment is made until the expense arises. To the basic rate of the room selected by John Jones is added a fixed or graduated sum to cover the cost of all extras. The patient who does not incur extra expenses helps to pay for the patient who does.

The items included among these "extras" are subject to variation. If the added charge covers nothing more than actual hospital services, the system has much to recommend it. The fact is, however, that almost every one of the writers advocating the system has proposed that, in addition to the many hospital services provided, certain medical services be included in the inclusive rate charged by the hospital. Here we have a fundamental and profound departure from the accepted and approved methods of medical practice. What medical services are to be included? By what arrangement will the hospital charge and collect for the services of physicians? How will the physician be compensated? Can a hospital corporation legally and ethically sell the services of licensed physicians? What would be the ultimate effect of such a development on the status of medical practice?

It is said that some 75 to 90 per cent of the special services of a hospital are customarily included in the fixed room charge. Now, if the room rate is increased to include the remaining 10 to 25 per cent of these special hospital services, the system presents no implications for the practice of medicine. By raising the room charge a specified amount, additional charges for special drugs, sera, special nursing, special dressings, oxygen, transfusions, operating room, delivery room, et cetera, can be eliminated. But the advocates of the system have gone further.. Many of them have proposed that the inclusive rate be increased to include the services of a radiologist, a pathologist, an anesthesiologist, and other medical specialists. Others have proposed that the fixed hospital charge include complete medical and surgical care.

A fixed inclusive rate to include all possible hospital services may be a wise and sound innovation in hospital accounting procedures. But when a hospital sets up a limited insurance plan for medical services, it is exceeding its domain and creating serious complications in medical practice. This has all been extensively discussed in connection with group hospitalization plans, and the American Medical Association has, through its House of Delegates, consistently pointed out the dangers of offering medical services as a part of hospital care in hospital insurance schemes. Precisely the same objections are present when medical services are included by the hospital in its fixed charges for hospital care.

Before discussing some of these objections and disadvantages, we should explain in more detail the various applications of the inclusive-rate principle. In application, the various modifications of the principle fall within the following classification:

(1) So-called "middle-rate" plan: This plan was inaugurated under the aegis of the Rosenwald Foundation at the Baker Memorial Hospital in Boston, the institution itself being an experiment in hospital economics.[2] The hospital was built under a gift for the hospitalization of patients of moder-

[1]Altvater, F. V.: Hospital Rates for 4½ Years. Modern Hospital **49:** 47, December 1937; Theory and Application of Inclusive or Flat Rate Plans. Hospitals **14:** 63, October 1940.

Hamilton, J. A.: Inclusive Rates. Hospitals **15:** 38, February 1941.

Class, J. V.: Stabilizing Charges for Hospital Service through Inclusive Rates. Hospitals **15:** 51, March 1941.

Root, V. T.: Room and Service Are Important in Establishing Inclusive Rates. Hospital Management **51:** 23, June 1941.

[2]Rorem, C. R.: The Middle-Rate Plan for Hospital Patients. Julius Rosenwald Fund Publications, Chicago, 1931.

ate means, between those in the charity wards of Massachusetts General Hospital and the well-to-do in the adjoining Phillips House. Thus the term "middle-rate." Under this plan, the social service department of the hospital sets the complete cost to be borne by each patient admitted, in view of the nature of his condition and his individual circumstances. The fee thus determined includes hospital accommodations, special services, and complete medical or surgical care. Staff physicians participating in the care of the patient are paid from the total sum collected on an agreed fee schedule.

This plan has not been widely copied for obvious reasons. It was introduced under the same sponsorship in Keokuk, Iowa, and abandoned after one year. Except for the fact that a third party determines the doctor's fee, it presents no particular problem in medical practice. Essentially, it entails nothing more than an agreement by staff physicians to treat patients in a designated income bracket at reduced fees, the hospital collecting the fee and turning it over to them. To this extent, it is not an "inclusive-rate" plan in the sense we are discussing that system here. It provides an answer to both of the questions discussed above, predetermining the total expense to be incurred regardless of the extent of treatment or length of stay.

(2) "Fixed" or "flat" rate plan: Under this plan, a patient's hospital bill is determined by the service on which he is admitted, that is to say, a predetermined flat sum is charged if admission is for tonsillectomy, a different sum for a maternity case, et cetera. This plan has various modifications and has not been widely adopted. It differs from the "middle-rate" plan in that the hospital does not determine nor collect fees for the services of physicians. It answers one of the questions referred to, predetermining the hospital bill regardless of the period of hospitalization. Charges for specialists' services for diagnosis and treatment or consultation are extra.

(3) "Inclusive-rate" plan: Certain features of this plan may be included in either one of the first two above. Its distinguishing characteristic is the lumping of all hospital charges into an unitemized "inclusive" rate. Some minor applications of the theory are no doubt employed in all hospitals. But only a few institutions have extended the principle to include certain medical services in the "inclusive" rate for hospitalization, which is the particular point for consideration here.

The general principle is usually applied under one of two basic formulae. In the first, the extras covered by the inclusive rate are added to the basic room rate under a graded plan, highest for the first day and gradually decreasing until the extra charge is eliminated. For example, to a basic room rate of $5.00 there may be added $8.50 for the first day, making a total inclusive rate of $13.50. For the second day, the rate would be $5.00 plus $5.00, or $10.00, and so on until the extra charge is dropped after the seventh or eighth day. The total added charge usually amounts to $20.00 to $35.00.

Under the second formula, a flat extra charge is added to the daily room rate, regardless of the length of stay. For example, a $1.00 or $2.00 service charge may be added, making the daily rate for a $5.00 room $6.00 or $7.00.

The patient's hospital bill includes all hospital and medical services with the exception of his attending physician's fee, but it varies according to the number of days in the hospital. Thus the "inclusive-rate" plan differs from the "fixed-rate" plan.

(4) Another adaptation of the essential theory of all these plans is the so-called "diagnostic rate." A fixed charge is made for "diagnosis" for a twenty-four or forty-eight-hour stay in the hospital by ambulatory patients requiring extensive diagnostic procedures. For example, the patient may be admitted on the advance payment of $35.00 or $50.00 and receive, besides room and board for twenty-four hours, roentgen examination, laboratory tests and pathological studies, electrocardiography, metabolic tests, in fact every special service desired by his attending physician.

There can be no denying that under this system the hospital is competing with private physicians in their own offices. All the special medical procedures and consultative services offered in this diagnostic bargain are available in the offices of private physicians. Thus the hospital, a corporation, competes in the practice of medicine with the members of its own staff. This is an unexpected rôle of the hospital, which owes its existence to the doctors in the community comprising its staff.

Now, what are some of the disadvantages of a system of inclusive fees which offers medical services in the per diem charge for hospital room?

(1) The first disadvantage is so compelling that others may well be superfluous. It is this: a hospital cannot, under the law, engage in the practice of medicine. When it sells the services of physicians, including the charge for these services and collecting therefor in a flat or inclusive rate, it is in fact engaged in the practice of medicine.[3]

(2) Patients who clearly understand the theory of the inclusive rate will object to paying for a medical service they do not enjoy. This objection has been minimized by certain writers, but it can hardly be avoided if every patient is told exactly what his increased room rate includes. He knows it includes "extras" and is assured that he would have to pay for them separately otherwise. But, does he know that he is paying for a roentgen consultation, the service of an anesthesiologist, and a specialist in clinical pathology, even though he may not require their attention? If he knows that, will he be entirely pleased if his particular case requires none of these?

[3]Cahal, M. F.: Employment of Physicians by Hospitals: Some Legal Aspects. Radiology **36**: 237, August 1941, *et seq.*

As an individual, this writer can answer that question for himself without hesitancy. When his daughter was born in an inclusive-rate hospital last year, he objected strenuously to paying $11.00 for an $8.00 room when there was no need for most of the services to which the patient was entitled. Of course, a patient would not object if he received without extra charge numerous expensive diagnostic procedures for which the man across the hall was paying. But the man across the hall might object if he were paying the cost of them for somebody else.

(3) Medical procedures included in the flat charge will be wastefully used. Experience has indicated that the work of the roentgen department just about doubles under a system by which hospital patients pay for these medical services whether they need them or not. This is to be expected. There is a natural tendency for both the patient and the attending physician to abuse the privilege thus purchased. The radiologist in one flat-rate hospital has made the confidential observation that free x-ray had a tendency to supplant diligent use of the stethoscope. Another has said quite frankly that a few attending men on his staff occasionally requested unnecessary roentgen examinations for the simple purpose of impressing their patients.

Is this good economics? Without disputing that the system will result in roentgen consultation in some cases which otherwise would go without it because the patients preferred to avoid the expense, the fact remains that, like so many attractive proposals for eliminating the financial burdens of illness, the disadvantages are likely to outweigh the advantages. It is hard to see how the cost of hospitalized illness can be reduced by making patients pay an increased amount, at least a portion of which is almost certain to pay for injudiciousness or for downright abuse. How can the per-patient cost of roentgen examination be reduced by doubling it?

(4) This inevitable increase in the amount of work performed in the medical departments of radiology and pathology, for instance, is bound to lead to the most egregious evil of all, an adulteration in the quality of professional service rendered. Unless expenses are increased at the same rate as demand—which they will not be—an examination which normally requires thirty minutes of a radiologist's time and a half dozen films will be disposed of in ten minutes with a couple of films.

(5) Whether or not it is a disadvantage, from the hospital's point of view, one implication of the inclusive rate system should give the medical profession serious pause. We have already discussed the various types of inclusive plans. What is to prevent a hospital which is permitted to establish one plan including medical services from subsequently combining it with another? If it can offer hospital accommodations, plus the services of radiologists, pathologists, cardiologists, physical therapists, and anesthesiologists for a flat rate of $10.00 per day, what is to prevent it from employing an obstetrician on a salary and offering a "middle-rate" plan with complete maternity care for a flat rate of $150.00 or $200.00?[4] It could sell surgery on the same basis. It could employ internists on a salary and render complete medical service at a per diem rate. It could, in short, enter and engage in the practice of medicine through the medium of employed physicians.

A likely result would be price competition between hospitals, consequent reduction in the size and quality of the employed staff, solicitation of patients, and inevitable adulteration in the medical services offered.

(6) The only practical way a hospital can include the services of physicians in the rate it charges for its rooms is to employ physicians on a salary, paying their salaries out of the gross income from room charges. We have already shown that this practice raises a question of law. Furthermore, it is contrary to the code of ethics of the medical profession.[5]

Of course, if the medical service is provided on a fee basis, the hospital merely collecting the fee for the doctor as in the "middle-rate" plan, the legal or ethical question is not raised. But if the hospital itself offers the services of consultants or diagnostic specialists in the charge it makes for its rooms, it is exceeding the domain ascribed to it in the care of the sick.

The objections of the radiologist to the inclusive-rate proposal are disposed of with refreshing candor by one advocate of the system. He says, "With regard to arrangements with roentgenologists, it can probably be dismissed by saying that, where such rate plans are adopted, an occasional contract may have to be revised in detail in so far as the professional man's remuneration is concerned. But no real difficulty should be encountered if there is a spirit of tolerance, co-operation, and imagination."[6]

Imagination, indeed! It requires little imagina-

[4]Some hospitals are already selling complete "maternity service," and others propose the sale of "tonsillectomies."

[5]". . .It would seem that in this time of extensive changes in hospital economics the point had arrived at which further marriages between hospitals and staff physicians that make the doctor of medicine the servant of the hospital should be stopped and a series of attempts at divorce among marriages that have already taken place should be instituted. Our accepted ethical principles are adequate at the present time and the cooperation of the Council on Medical Education and Hospitals would be of invaluable assistance. It is not an impossible task, but will need a militant local and national ethical spirit behind it and a frowning on those individuals in the profession who on personal grounds do not object to the gradual subjugation of the medical profession in the growth of hospital domination." Judicial Council of the American Medical Association, J. A. M. A. **106:** 1197, April 4, 1936.

[6]Hospitals, June 1941, p. 14.

tion to recognize in this glib statement a proposal of profound importance to medicine. Shall the practice of medicine be controlled by hospitals or doctors?

Suppose the hospital-employer finds difficulty in balancing its budget. Will it cut physicians' salaries? Or will it replace experienced men of recognized ability with younger physicians or men of less competence who are willing to take half the former man's salary? Radiologists and pathologists who have consented to work on a straight salary in a hospital have seen this very thing happen too often to regard it as a remote possibility. For the same room rate, a patient might get a $5,000 or $10,000 surgeon; that would be up to the choice of the hospital. It would determine the quality of medical service it could afford to offer in its bargain rate.

Already a few of the large group hospitalization plans, against the persistent objections of the organized medical profession, have included the services of certain physicians as a part of "hospital care." Suppose the "time" factor is added to the "group" factor and the insurance principle is engrafted upon the "inclusive-rate" plan. Suppose then the "inclusive rate" which includes some medical service is combined with the "middle-rate" plan to provide complete medical care. Then we have a lay-managed corporation selling complete medical care on a prepayment basis through the medium of employed physicians.

That this is no idle hypothesis is indicated by a statement by C. R. Rorem in a report on the Boston "middle-rate" plan:

"Any really effective attack will not merely make it easier for the patient to pay his sickness bills after illness occurs, but will enable him to budget for them in advance."[7]

Organized medical societies are rapidly installing plans to permit patients to budget for medical care through prepayment. Hospitals are doing the same for hospital care. They should not, however, either in insurance plans or "inclusive-rate" plans, be permitted to sell medical services along with their hospital facilities. It is the responsibility of county medical societies in all communities where attempts are made to extend the functions of the hospital in this manner to point out the inherent dangers by prompt and appropriate action.

MAC F. CAHAL

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[7]Rorem, C. R.: How Do Physicians and Patients Like the Middle-Rate Plan for Hospital Care? Julius Rosenwald Fund Publications, Chicago, 1932, p. 13.

RADIOLOGICAL SOCIETIES OF NORTH AMERICA

Editor's Note.—Will secretaries of societies please cooperate with the Editor by supplying information to keep these notices accurate and up to date? Please send information to Howard P. Doub, M.D., Henry Ford Hospital, Detroit, Mich.

UNITED STATES

Radiological Society of North America.—Secretary, D. S. Childs, M.D., 607 Medical Arts Building, Syracuse, N. Y.

American Roentgen Ray Society.—Secretary, C. B. Peirce, Royal Victoria Hospital, Montreal, Canada.

American College of Radiology.—Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual Meeting, 1942, Atlantic City, N. J.

Section on Radiology, American Medical Association.—Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual Meeting, 1942, Atlantic City, N. J.

CALIFORNIA

California Medical Association, Section on Radiology.—Secretary, Joseph D. Coate, M.D., 434 Thirtieth St., Oakland.

Los Angeles County Medical Association, Radiological Section.—Secretary, Wilbur Bailey, M.D., 2007 Wilshire Blvd.; Meets second Wednesday of each month at County Society Building.

Pacific Roentgen Society.—Secretary-Treasurer, L. Henry Garland, M.D., 450 Sutter St., San Francisco. Society meets annually during annual meeting of the California Medical Association.

San Francisco Radiological Society.—Secretary, J. Maurice Robinson, M.D., University of California Hospital. Meets monthly on third Thursday at 7:45 P.M., for the first six months at Toland Hall (University of California Medical School) and for the second six months at Lane Hall (Stanford University School of Medicine).

COLORADO

Denver Radiological Club.—Secretary, Edward J. Meister, 366 Metropolitan Bldg. Meetings third Friday of each month at the Denver Athletic Club.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Secretary-Treasurer, Max Climan, M.D., 242 Trumbull St., Hartford. Meetings bimonthly, on second Thursday. Place of meeting selected by Secretary.

FLORIDA

Florida Radiological Society.—Secretary-Treasurer, Walter A. Weed, M.D., 204 Exchange Building, Orlando. The next meeting will be at the time of the annual meeting of the Medical Association of Florida, April 13–15, 1942, at Palm Beach.

GEORGIA

Georgia Radiological Society.—Secretary-Treasurer, Robert C. Pendergrass, M.D., Prather Clinic Bldg., Americus. Meetings twice annually, in November and at the annual meeting of the Medical Association of Georgia in the spring.

ILLINOIS

Chicago Roentgen Society.—Secretary, Chester J. Challenger, M.D., 3117 Logan Blvd. The Society meets at the Palmer House on the second Thursday of October, November, January, February, March, and April.

Illinois Radiological Society.—Secretary-Treasurer, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—Secretary, Earl E. Barth, M.D., 303 E. Chicago Ave., Chicago.

INDIANA

The Indiana Roentgen Society.—Secretary-Treasurer, Harold C. Ochsner, Methodist Hospital, Indianapolis. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—Secretary-Treasurer, Joseph C. Bell, M.D., 402 Heyburn Bldg., Louisville. Meeting annually in Louisville, third Sunday afternoon in April.

LOUISIANA

Louisiana Radiological Society.—Secretary-Treasurer, Johnson R. Anderson, M.D., North Louisiana Sanitarium, Shreveport. Meets annually at same time as State Medical Society. Next meeting, New Orleans, April 1942.

Shreveport Radiological Club.—Secretary-Treasurer, W. R. Harwell, M.D. Meetings monthly on the second Wednesday, at the offices of the various members.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Secretary, Walter L. Kilby, M.D., 101 W. Read St. Meetings are held the third Tuesday of each month.

MICHIGAN

Detroit X-ray and Radium Society.—Secretary-Treasurer, E. R. Witwer, M.D., Harper Hospital, Detroit. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society club rooms, 4421 Woodward Ave., Detroit.

Michigan Association of Roentgenologists.—Secretary-Treasurer, J. E. Lofstrom, M.D., St. Mary's Hospital, Detroit. Meetings quarterly by announcement.

MINNESOTA

Minnesota Radiological Society.—Secretary, John P. Medelman, M.D., 572 Lowry Medical Arts Bldg., St. Paul. Meetings quarterly.

MISSOURI

The Kansas City Radiological Society.—Secretary, P. E. Hiebert, M.D., 907 North Seventh St. (Huron Bldg.), Kansas City, Kansas. Meetings last Thursday of each month.

The St. Louis Society of Radiologists.—Secretary, Wilbur K. Mueller, M.D., University Club Bldg. Meets on fourth Wednesday of October, January, March, and May, at a place designated by the president.

NEBRASKA

Nebraska Radiological Society.—Secretary, D. A. Dowell, M.D., 816 Medical Arts Bldg., Omaha. Meetings third Wednesday of each month at 6 P.M. in either Omaha or Lincoln.

NEW ENGLAND

New England Roentgen Ray Society (Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island).—*Secretary,* Hugh F. Hare, M.D., Lahey Clinic, Boston, Mass. Meets monthly on third Friday at Boston Medical Library.

NEW JERSEY

Radiological Society of New Jersey.—Secretary, H. J. Perlberg, M.D., Trust Co. of New Jersey Bldg., Jersey City. Meetings at Atlantic City at time of State Medical Society and midwinter in Newark as called by president.

NEW YORK

Associated Radiologists of New York, Inc.—Secretary, William J. Francis, M.D., 210 Fifth Ave., New York City. Regular meetings the first Monday evening of the month in March, May, October, and December.

Brooklyn Roentgen Ray Society.—Secretary-Treasurer, Leo Harrington, M.D., 880 Ocean Ave. Meetings held the fourth Tuesday of every month, October to April.

Buffalo Radiological Society.—Secretary-Treasurer, Joseph S. Gianfranceschi, M.D., 610 Niagara St. Meetings second Monday evening each month, October to May, inclusive.

Central New York Roentgen Ray Society.—Secretary-Treasurer, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse. Meetings are held in January, May, and October, as called by Executive Committee.

Long Island Radiological Society.—Secretary, Marcus Wiener, M.D., 1430 48th St., Brooklyn. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—Secretary, Paul C. Swenson, M.D., Presbyterian Hospital, New York, N. Y.

Rochester Roentgen-ray Society.—Secretary, S. C. Davidson, M.D., 277 Alexander St. Meetings at convenience of committee.

NORTH CAROLINA

Radiological Society of North Carolina.—Secretary-Treasurer, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meeting with State meeting in May, and meeting in October.

NORTH DAKOTA

North Dakota Radiological Society.—Secretary, L. A. Nash, M.D., St. John's Hospital, Fargo. Meetings by announcement.

OHIO

Ohio Radiological Society.—Secretary, J. E. McCarthy, M.D., Cincinnati. The next meeting will be held at the time and place of the annual meeting of the Ohio State Medical Association.

Cleveland Radiological Society.—Secretary-Treasurer, J. O. Newton, M.D., 13921 Terrace Road, East Cleveland. Meetings at 6:30 P.M. at the Mid-day Club, in the Union Commerce Bldg., on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*Secretary-Treasurer,* Justin E. McCarthy, M.D., 707 Race St. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—Secretary-Treasurer, L. E. Wurster, M.D., 416 Pine St., Williamsport. The Society meets annually; time and place of next meeting will be announced later.

The Philadelphia Roentgen Ray Society.—Secretary, Barton R. Young, M.D., Temple University Hospital, Philadelphia. Meetings held first Thursday of each month at 8:15 P.M., from October to May, in Thomson Hall, College of Physicians, 21 S. 22nd St., Philadelphia.

The Pittsburgh Roentgen Society.—Secretary-Treasurer, Harold W. Jacox, M.D., 4800 Friendship Ave., Pittsburgh, Pa. Meetings are held on the second Wednesday of each month at 4:30 P.M., from October to June, at the Pittsburgh Academy of Medicine, 322 N. Craig St.

ROCKY MOUNTAIN STATES

Rocky Mountain Radiological Society (North Dakota, South Dakota, Nebraska, Kansas, Texas, Wyoming, Montana, Colorado, Idaho, Utah, New Mexico).—*Secretary,* A. M. Popma, M.D., 220 North First St., Boise, Idaho.

SOUTH CAROLINA

South Carolina X-ray Society.—Secretary-Treasurer, Malcolm Mosteller, M.D., Columbia Hospital, Columbia. Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—Secretary-Treasurer, Franklin B. Bogart, M.D., 311 Medical Arts Bldg., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Texas Radiological Society.—Secretary-Treasurer, L. W. Baird, M.D., Scott and White Hospital, Temple. Meets annually.

VIRGINIA

Virginia Radiological Society.—Secretary, Charles H. Peterson, M.D., 603 Medical Arts Bldg., Roanoke.

WASHINGTON

Washington State Radiological Society.—Secretary-Treasurer, Kenneth J. Holtz, M.D., American Bank Bldg., Seattle. Meetings fourth Monday of each month at College Club, Seattle.

WISCONSIN

Milwaukee, Roentgen Ray Society.—Secretary-Treasurer, Irving I. Cowan, M.D., Mount Sinai Hospital, Milwaukee. Meets monthly on first Friday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, Russel F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

CANADA

Section on Radiology, Canadian Medical Association.—Secretary, W. J. Cryderman, M.D., Medical Arts Bldg., Toronto.

Section on Radiology, Ontario Medical Association.—Secretary, W. J. Cryderman, M.D., 474 Glenlake Avenue, Toronto.

Canadian Association of Radiologists.—Honorary Secretary-Treasurer, A. C. Singleton, M.D., Toronto.

La Société Canadienne-Française d'Eléctrologie et de Radiologie Médicales.—General Secretary, Origène Dufresne, M.D., Institut du Radium, Montreal. Meetings are held the third Saturday of each month, generally at the Radium Institute, 4120 East Ontario Street, Montreal; sometimes, at homes of members.

CUBA

Sociedad de Radiología y Fisioterapia de Cuba.—Offices in Hospital Mercedes, Havana. Meetings are held monthly.

ABSTRACTS OF CURRENT LITERATURE

ROENTGEN DIAGNOSIS

The Head and Neck

The Chest

The Digestive Tract

The Skeletal System

Niemann-Pick's Disease

RADIOTHERAPY

Malignant Tumors

Non-Malignant Conditions

Experimental Studies

ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Hyperostosis of the Calvarium. C. L. Williams. J. Indiana M. A. **34:** 361, July 1941.

The author has studied the history and literature on hyperostosis of the calvarium, giving a thorough review of the various findings of different writers and their theories as to its cause.

Roentgenographically, the changes consist in thickening of the inner table of the skull, localized or diffuse. Clinical observations are obesity, virilism, and neuropsychiatric changes. Obesity is usually marked and frequently of the rhizomelic type. Virilism, as a rule, is manifest by hirsutism. The psychiatric manifestations are varied, from psychoneurosis to senile dementia. The neurological changes are due to thickening of the bone at the various foramina through which the cranial nerves pass.

The usual symptoms are headache, memory defects, menstrual disorders, mental changes, dizziness, weakness and easy fatigability, visual disturbances, convulsive and epileptiform manifestations, muscular defects, disturbances of equilibrium and gait, and speech difficulty. The basal metabolic rate is decreased.

For the present study 27 females and one male showing the clinical picture of this disease were selected from the neuropsychiatric wards. Of this group, 19 were found to have hyperostosis. The sella turcica was studied in detail in these patients. In 12 it was classified as normal; in 4 it showed enlargement; in 2 flattening and elongation; and in 2 the posterior clinoids were more perpendicular than normal. Of special interest is the almost constant finding of an indistinct or effaced coronal suture in these cases. In only one or two instances was a short wavy shadow of the coronal suture found. Normally ossification of this suture begins at about forty years and continues until eighty years. It would seem that the same process that causes the hyperostosis is responsible for the early closure of the coronal suture. The author believes that all these changes may be due to some endocrine dysfunction.

J. B. McAneny, M.D.

The Arnold-Chiari Malformation: Diagnosis, Demonstration by Intraspinal Lipiodol and Successful Surgical Treatment. R. D. Adams, R. Schatzki, and W. B. Scoville. New England J. Med. **225:** 125–131, July 24, 1941.

The so-called Arnold-Chiari malformation is a congenital malformation of the medulla and cerebellum, both of which are herniated through the foramen magnum into the cervical spinal canal, leading to obstruction in the cerebrospinal circulation with production of hydrocephalus, stretching of the lower cranial nerves, compression of the spinal cord and medulla, and deformity of the cerebellum. A meningomyelocele and thickening of the basal meninges frequently accompany this anomaly.

Headache is an important symptom. It is of the cerebellar type, located in the occipital or cervical region, occurring suddenly, usually at night or early in the morning, accompanied by nausea and vomiting. Papilledema is usually slight. Cranial nerve injury is due to stretching as a result of descent of the brain stem into the foramen magnum and spinal canal. The third, seventh, ninth, tenth, and twelfth cranial nerves were involved bilaterally in one of the authors' cases. Compression of the brain stem produces nausea and vomiting, disturbed conjugate movement of the eyes, and vertical nystagmus. Cerebellar signs consist in slight gait disturbances, intention tremor, or incoordination of movement. Compression of the spinal cord results in bilateral pyramidal-tract signs.

Lumbar puncture shows a complete block in the circulation of the cerebrospinal fluid with no rise in pressure on jugular compression, but a definite rise on coughing. Spinal fluid protein is increased.

The myelographic appearance seems to be characteristic. There is a mass in the upper cervical region producing a block which permits some lipiodol to pass into the skull but hinders its exit. The mass is less distinctly outlined than a tumor would be and often presents lobulations produced by the gyri of the cerebellum. A small central incisura is seen within the mass, corresponding to the incisura between the two cerebellar tonsils. Some degree of platybasia may be present in these patients.

Operation is seldom successful, though in each of the cases reported here the patient survived. Cerebellar and high cervical decompression are probably the wisest measures.

J. B. McAneny, M.D.

Diagnosis and Treatment of Expanding Lesions of the Cranial Cavity. William R. Lipscomb. Rocky Mountain M. J. **138:** 553–561, July 1941.

The author sketches briefly the development of modern neurosurgery. Outstanding figures are Hughs Bennett and Richman Godlee of London, who reported the first case of cerebral tumor diagnosed by newer neurological methods and accomplished an unheard-of feat by removing the tumor; Weir, the first American surgeon to remove a brain tumor successfully, in 1887; Harvey Cushing, who in 1908 became the leading exponent of neurosurgery; Dandy, who in 1919 introduced the method of diagnosis of cerebral lesions by replacing fluid with air and taking roentgenograms.

The symptoms of intracranial tumors may be divided into two groups: those of increased intracranial pressure and those of a localizing nature.

Headache, vomiting, and choked disc are the cardinal symptoms of increased intracranial pressure. Of these, headache is usually the first to make itself known. Choked disc, or papilledema, in the absence of headache and vomiting may signify a retrobulbar neuritis rather than increased intracranial pressure. One type of expanding intracranial lesion, a pituitary tumor, may not cause papilledema until it is large enough to produce third ventricle compression. These tumors usually produce bitemporal hemianopsia and optic atrophy in the early stages of their growth from direct pressure on the optic nerves. Intraventricular tumors, on the other hand, produce increased intracranial pressure and papilledema early.

Expanding lesions which primarily involve motor, sensory, visual, auditory, olfactory, and other special areas, may produce localizing signs before they produce evidence of increased pressure.

Not only neoplasms, but traumatic, inflammatory, and vascular lesions must be kept in mind when the symptoms and signs of increased intracranial pressure present themselves. If a patient gives a history of head injury, depressed fracture of the skull, extradural and intracerebral hematoma must be considered. If there is a history of pulmonary abscess, bronchiectasis, empyema, endocarditis, otitis media, mastoiditis, or sinusitis, the doctor must be suspicious of an intracranial inflammatory lesion, such as meningitis, brain abscess or encephalitis. Syphilis must be borne in mind at all times. Familial diseases of the brain to be differentiated from expanding lesions are rare. Periodic familial paralysis, however, amaurotic family idiocy, Huntington's chorea, and feeble-mindedness may be confused with expanding intracranial lesions. Metastatic neoplasms must not, of course, be overlooked. Vascular lesions include—in addition to hematomata—thromboses, emboli, arteriovenous fistulas, aneurysms, hem-

angiomas, and hemorrhages. Because aneurysms and arteriovenous fistulas are frequently located about the cavernous sinus, external ocular palsies, periorbital congestion, amaurosis, and pulsating exophthalmos are present before signs of increased intracranial pressure, which results from rupture of the aneurysm. The finding of bloody spinal fluid under increased pressure is pathognomonic. Unless a cranial bruit is heard before the fistula ruptures, the patient may be operated upon in the expectation of finding a perisellar neoplasm.

Brain tumors comprise some 2 per cent of all tumors. About 50 per cent are gliomas or primary non-encapsulated tumors arising from cerebral tissue; the others are encapsulated tumors. Those arising from the arachnoid, particularly the villi, called meningiomas or dural endotheliomas, or psammomas or hemangioendotheliomas, make up about 18 per cent of the total; 14 per cent are pituitary tumors; 9 per cent are eighth nerve tumors (cerebellopontine angle neurinomas or acoustic neurinomas). The remaining 9 per cent is made up of granulomas, craniopharyngiomas, lipomas, and many other varieties, including metastatic deposits.

Seventy-five per cent of all brain tumors are located supratentorially; most of this group are to be found in adults. The infratentorial tumors occur mostly in children, acoustic neurinomas being the chief exception. The infratentorial tumors of childhood are chiefly medulloblastomas, arising from the anterior medullary velum of the vermis of the cerebellum and encroaching upon the fourth ventricle, producing an early internal hydrocephalus with headache, nausea, vomiting, blurred vision from the high papilledema, ataxia, hiccough, stiff neck, etc. The treatment of choice for medulloblastomas is high-voltage x-ray therapy, the tumor cells being very sensitive to the gamma rays. The improvement is dramatic, but recurrences are the rule and the cells become radioresistant. Medulloblastomas and pinealomas are the two principal brain tumors which metastasize.

The other glioma which occurs in children, especially below the tentorium, is the cystic astrocytoma. Surgical drainage with removal of mural tumor through a suboccipital craniotomy may effect a complete cure.

The most common glioma is the spongioblastoma multiforme, otherwise known as glioblastoma multiforme, which makes up nearly half of all the gliomas, or one fourth of the brain tumors. It usually occurs after middle life and grows rapidly, with early symptoms. It is invasive and difficult of total removal.

Six cases are reported. In the first, a vascular glioma, ventriculography revealed a displacement of the right lateral ventricle toward the left. In the second, a protoplasmic astrocytoma, operation was followed by recovery. The third showed definite x-ray findings, the sella being eroded with widening of the middle meningeal channel and an enostosis near the sagittal suture. This at operation proved to be a meningioma. Recovery ensued. The fourth case was one of acoustic neurinoma in which x-ray demonstrated some erosion of the petrous pyramid. The patient died of postoperative pulmonary complications. The fifth patient had a brain abscess; the x-ray demonstrated some cranial osteomyelitis. The sixth case, a hemangioblastoma, gave no significant x-ray findings. Operation resulted in recovery with no return of symptoms.

PERCY J. DELANO, M.D.

A Roentgenographic Cephalometric Appraisal of Untreated and Treated Hypothyroidism. Milton B. Engel, I. P. Bronstein, Allan G. Brodie, and Phillip Wesoke. Am. J. Dis. Children **61:** 1193–1214, June 1941.

This is a report on craniofacial growth in children with thyroid deficiency, based on a study of 13 selected cases of hypothyroidism from a series of 27 classic examples. Cephalometric lateral roentgenograms were taken of the skull of each patient and measurements from the various craniofacial landmarks were made to determine the relative development of the component parts of the skull and facial bones. Measurements of treated and untreated patients and normal controls were compared. The studies of each patient were complete and included analyses of the dental development and carpal ossification patterns.

Craniofacial, dental, and carpal ossification developmental patterns of untreated children with hypothyroidism lag behind those of children given thyroid therapy. The deficiency in the cranium lies in the occipital, the parietal and, to much lesser extent, the frontal area. The cranial base is shortened, and the sphenooccipital synchondrosis and the sutures of the vault are abnormally wide. The face shows a generalized retardation of growth as a result of the slowed velocity of growth of its components, that is, the mandible, the maxilla, and the nasal bone. The teeth are delayed in their eruption, but are not malformed. Differentiation and ossification of carpal centers are disturbed and retarded, and the roentgenograms show persistence of infantile characters.

Craniofacial, dental, and carpal patterns of development in untreated children with hypothyroidism are retarded when compared to those of normal subjects of the same age. The differences are merely an accentuation of those noted between treated and untreated cretins.

Children with hypothyroidism who have been treated regularly since early childhood closely approach normal levels of craniofacial development. Their pattern of dental development and progress in ossification are normal.

Thyroid deficiency affects craniofacial growth by retarding its velocity rather than by modifying its pattern.

GEORGE M. WYATT, M.D.

The Mouth in Hyperparathyroidism. M. S. Strock. New England J. Med. **224:** 1019–1023, June 12, 1941.

With all the literature on hyperparathyroidism, very little is written about the changes found in the mouth. A review of 45 cases shows that the usual findings are visible or palpable tumors of the jaw, malocclusion or distortion of the normal arrangement of the teeth, cystlike cavities in the jaw, diminished dental caries, osteoporosis, closely meshed trabeculae, and absence of the lamina dura.

The loss of calcium content in the jaw permits the tongue and muscles to distort the normal alignment of the teeth. The finding of cysts other than those of infectious origin and tumors of the jaw should lead one to think of hyperparathyroidism. Caries is diminished in this disease, which suggests that calcium cannot be withdrawn from the teeth. The bone structure of the jaw is markedly changed. There is a loss of the normal trabecular structure and the bone takes on a fine lacelike appearance suggesting ground glass. There is a decided contrast between the dense teeth and the relatively lucent bone. The lamina dura disappears, due to calcium absorption of this dense bone about the roots.

JOHN MCANENY, M.D.

THE CHEST

Rôle of Mass Radiography in Tuberculosis. G Jessel. Brit. J. Radiol. **14:** 206–209, June 1941.

The diagnosis of early tuberculosis is capable of considerable improvement. X-ray examination, valuable as it is, records the conditions only at the moment of examination. Mass radiography is valuable for screening out the healthy members of the population. The

others should have subsequent complete examinations, and those who are classed as healthy should have examinations at suitable intervals, depending on the dangerousness of their occupation.

Mass surveys should be undertaken as investigations of the general health and not as specifically tuberculosis investigations.

Definite standards of interpretation should be set up and the films should be read by teams of experienced radiologists.

SYDNEY J. HAWLEY, M.D.

Choice of Procedure in Treatment of Tuberculous Cavities. L. Eloesser. J. Thoracic Surg. **10:** 501–522, June 1941.

There are three fundamentally different therapeutic methods for closing tuberculous pulmonary cavities: collapse, compression, and aspiration.

For *collapse treatment* pneumothorax is first instituted. This treatment presupposes that a lung which is freed from the pull of the chest wall will collapse by virtue of its elasticity and that the cavities, which are likewise held open by the pull of the chest wall, will also collapse. If the cavity remains open there may be adhesions present which can be cut. If the cavity persists, thoracoplasty of various degrees may be done in an effort to free the lung.

Compression methods for closing cavities are intended to squeeze the cavity directly and consist of pressure pneumothorax and pressure with gauze or with paraffin. These methods are being discarded. Extrapleural pneumothorax falls in this group also and is used in certain cases. There still remain, however, many cavities which will not collapse when treated by any one or several of the compression and collapse forms of therapy.

Aspiration and suction drainage presuppose a cavity in which pressure is higher within the cavity than in the surrounding lung most of the time, so that it is actively ballooned out. In order to determine this state of affairs the author needles the cavities—only, however, if the pleural space is obliterated—and determines the pressures. After the pressure in the cavity in various phases of respiration has been measured, lipiodol and methylene blue are injected. If these substances get out of the cavities readily, the bronchi are not blocked. If, on the other hand, the evidence indicates that the bronchi leading to the cavities are partially blocked, it is decided that the ball valve mechanism results in a positive pressure within the cavity which keeps it open. In some cases the author has succeeded in closing these cavities by a single aspiration. In a few he has followed the aspiration with thoracoplasty to keep the cavities from re-expanding. In some cases a catheter is placed in the cavity and a more constant suction applied. In two cases where this procedure failed a skin flap was inserted into the cavity and a permanent communication made with the outside. This prevents ballooning of the cavity due to increased pressure from within.

The following conclusions are reached:

(1) Cavities with a wide open bronchus may be amenable to collapse therapy (pneumothorax or thoracoplasty).

(2) Cavities whose bronchi are blocked or partially blocked are probably not amenable to collapse therapy. This state of affairs can be determined by needling the cavities and measuring the pressures within.

(3) If there is a positive pressure in the cavities they may be collapsed by needle aspiration followed by thoracoplasty or by continuous catheter suction followed by thoracoplasty.

(4) A skin flap attached to the lumen of the cavity may be necessary in some cases to keep the pressure inside of the cavity at atmospheric levels.

HAROLD O. PETERSON, M.D.

Pleural Effusion in Artificial Pneumothorax Therapy at the Quezon Institute. Teodocio S. Santos. Bull. Quezon Institute **2:** 47–57, July 1941.

Of 1,148 tuberculous patients treated by pneumothorax, 49.9 per cent were found to have fluid in the pleural cavity as a complication of treatment. This condition is progressively less frequent during the first year of refills and occurs in about the same frequency for each month thereafter. It is 20 per cent more frequent in advanced cases than in those with minimal lesions. Fifty-five per cent of the patients showing fluid required one or more tappings. Approximately two-thirds more patients in the advanced group had an empyematous change in the primarily clear fluid than in the minimal group. Two per cent of the moderately advanced and 5 per cent of the far advanced cases were empyematous from the onset. The occurrence of fluid is usually associated with the abrupt appearance of fever, chest pain, gastric symptoms, or difficulty in respiration in patients who had been symptom-free for some time during the course of treatment.

W. H. GILLENTINE, M.D

Air Embolism in Artificial Pneumothorax Therapy (with Report of a Fatal Case). Miguel Canizares and Gavino C. Santiago. Bull. Quezon Institute **2:** 31–34, July 1941.

The most dreaded of the immediate complications in the treatment of pulmonary tuberculosis by pneumothorax is air embolism. The incidence as given in the literature ranges from 1 in 2,000 to 1 in 18,000 refills with fatality rates all the way from 15 to 50 per cent. The incidence at the Quezon Institute has been 1 in every 21,592 refills with a mortality rate of 11.1 per cent. Air may reach the vascular system from any of several sources. It may be introduced by the pneumothorax apparatus into a pleural blood vessel or may be aspirated from the pleural space; it may be sucked spontaneously from a cavity during a coughing attack. The condition is dangerous only when air enters a pulmonary vessel and thereby reaches the greater circulation. The symptomatology, outside of the general vasomotor shock reaction, apparently depends on the site of the embolus.

The authors regard the following points as indicating that the tip of the pneumothorax needle does not lie in the free pleural space: (1) jerky manometric oscillations; (2) a negative reading which fails to descend with the respiratory act; (3) excursions yielding readings of equal negative and positive values; (4) readings very close to zero. The treatment is that for other types of embolism of the brain and heart. The best measure is prevention, for this serious accident is almost always due to lung damage by the needle tip or introduction of air directly into a blood vessel.

A fatal case is reported.

W. H. GILLENTINE, M.D.

Tuberculous Cavitation and Transpleural Decompression. Harold Brunn, Sidney Shipman, Alfred Goldman, and Loren Ackerman. J. Thoracic Surg. **10:** 485–500, June 1941.

The authors believe that there are two factors necessary for the production of a cavity in the lung. These are, first, a disturbance in the integrity of the lung (caseous focus) and, second, bronchial stenosis. If the bronchus is wide open the liquefied caseous material will drain out and the normal elasticity of the lung will gradually cause the cavity to collapse. If there is a bronchial stenosis a ball-valve mechanism will tend to expand the cavity. A great deal of the bronchial stenosis is on an allergic basis and therefore reversible, accounting for those cavities which spontaneously open and close. Transpleural decompression on 20 cavities

in 18 patients were attempted. Catheters were inserted into the cavities through the chest wall and constant suction was applied by means of a motor-driven mechanical pump. Seven of the twenty cavities became smaller or closed or became negative for tubercle bacilli. The pleural cavity must be obliterated before this type of treatment is attempted.

The authors do not agree with the theory of Coryllos that atmospheric oxygen must be prevented from reaching the cavity in order that its tuberculous infection should die. Some cavities disappear with the bronchi wide open or in direct communication with the air through the chest wall. When standard forms of collapse therapy fail, transpleural decompression may be the solution, at least in some of the cases.

HAROLD O. PETERSON, M.D.

Spontaneous Closure of Tuberculous Cavities. E. R. Wiese. Am. Rev. Tuberc. **44:** 92–93, July 1941.

Among 1,000 cases of pulmonary tuberculosis studied, there were 125 with cavitation in which no form of collapse therapy was attempted. In reviewing these cases, the author found that in 20 of them spontaneous closure of the cavity took place with no other treatment than strict bed rest. In all instances of spontaneous closure, the cavities had been thin-walled and, as a rule, regular in outline. Usually the closure was manifested by gradual diminution in size of the cavity until one could see only a small fibrotic deposit or strands of fibrotic tissue.

L. W. PAUL, M.D.

Lung Blast. Thomas F. Rose. M. J. Australia **1:** 784–786, June 28, 1941.

This paper is based on the author's experience in the bombed areas in the East End of London. "Lung blast," or pulmonary concussion, is a hemorrhagic lesion of the lungs due to the effect of the detonation of high explosives. Typically, there is no injury to the chest wall and no bruising or fracturing of ribs, and the clinical onset is delayed for some time after the explosion. The illness begins with fever, signs of shock, and lung findings resembling the onset of pneumonia. The lungs show irregular areas of hemorrhage, most pronounced beneath the visceral pleura and roughly following the indentations of the ribs. The pulmonary damage seems to be due to the sudden and violent impact of the blast waves on the chest wall, and not to an air wave of suction or compression acting through the trachea. The portion of the chest involved is that facing the blast.

The pathological changes through which the hemorrhagic areas pass resemble roughly those found in pulmonary embolism or pulmonary rupture from other causes. The roentgenogram reveals mottled, woolly shadows corresponding in extent to the hemorrhagic areas, usually at the periphery of the chest.

The author somewhat grimly remarks, in discussing the prophylaxis of the condition, that as far as possible one should keep out of the way of bombs. Therapy is essentially that of shock and expectant treatment to the lungs. As these patients tolerate transportation badly, they should not be moved about more than is necessary. Gas anesthesia in bombed patients requiring surgical treatment is deplored because of the dilatation of capillaries and possible increase in hemorrhage produced by anoxemia. Sulfapyridine is useful in preventing infection of the damaged areas.

WM. H. GILLENTINE, M.D.

A Right-Sided Aorta. A. H. Gosse. Brit. J. Radiol. **14:** 215–216, June 1941.

A case of a right-sided aorta is reported. The lesion was discovered during an examination for pleurisy. The patient had no symptoms attributable to the aortic anomaly except occasional regurgitation of food.

SYDNEY J. HAWLEY, M.D.

Retro-Esophageal Right-Sided Aorta. R. Humbert. Schweiz. med. Wchnschr. **71:** 640–641, May 17, 1941.

The author reports three cases of right-sided aorta. The anterior study of the chest showed an abnormal bulge on the right side of the cardiovascular shadow, which was shown in the oblique view to be the aorta. The esophagus and trachea passed anteriorly to the arch instead of posteriorly.

This anomaly is due to an abnormal embryological development, and may take one of three forms: (1) persistence of both left and right aortic arches; (2) persistence of the right aortic arch and obliteration of the left (normal in birds); (3) persistence of the right aortic arch and partial obliteration of the left, which then forms a sort of diverticulum from which arises the left subclavian artery.

The first two of the cases reported belonged to the last category, while the third case belonged to the first.

LEWIS G. JACOBS, M.D.

Visualization of the Pulmonary Artery during Its Embolic Obstruction. Joseph H. Jesser and Geza de Takats. Arch. Surg. **42:** 1034–1041, June 1941.

This is a study of the effects of embolism and various drugs on the pulmonary circulation of dogs. Preliminary studies with the pulmonary vessels filled with barium paste showed that the right anterior and the left anterior oblique positions were optimum. In living dogs 15 to 20 c.c. of 25 per cent sodium iodide solution were injected in one second and films were made three and five seconds later, the former showing the superior vena cava, the right heart, and the pulmonary arterial tree, and the latter the pulmonary veins and the left heart.

Two grains of papaverine hydrochloride caused widening of the superior vena cava, the pulmonary conus, and the larger arterial branches. One cubic centimeter of 1:1,000 epinephrine hydrochloride solution caused a reflux into the venae cavae and a contraction of the pulmonary arteries. Embolism produced an engorgement of the right heart (cor pulmonale) and the venae cavae. Administration of papaverine after embolism abolished the cor pulmonale and increased the vascularity of the pulmonary bed.

The pressor effects of epinephrine thus tend to increase the ill effects of pulmonary embolism, and papaverine tends to diminish them.

LEWIS G. JACOBS, M.D.

THE DIGESTIVE TRACT

Pseudo-Neoplastic Radiologic Appearances of Gastroduodenal Ulcer. Diagnostic Importance of the "Therapeutic Test of Benignity." P. Savy, A. Vachon, and G. Romagny. J. de méd. de Lyon **22:** 267–272, June 1941.

Ulcers of the stomach and duodenum often produce radiologic evidences which simulate cancer and give rise to doubt concerning the real nature of the affection. These pseudo-neoplastic appearances are variable. Frequently niches are suspicious because of their form, size, or site; permanent deformities or lacunar images, generally prepyloric, are often the result of edematous gastritis in the region of the ulcer.

The practical interest of these pseudo-neoplastic appearances lies in the diagnostic difficulties which they engender. It is frequently necessary to prescribe rigorous medical treatment for a month (or more), then re-examine the patient for comparison. The ap-

plication of the therapeutic test will often permit recognition of the benign or malignant nature of the lesions and indicate the proper therapy.

The author presents in detail four case histories illustrating types of pseudo-neoplastic lesions. He is convinced that laboratory tests and gastroscopy do not furnish sufficiently reliable information for differential diagnosis and that the therapeutic test is the most accurate method. S. R. BEATTY, M.D.

Roentgen Changes in the Small Bowel in Sprue. H. W. Hotz and W. G. Deucher. Schweiz. med. Wchnschr. **71:** 748–750, June 14, 1941.

On the basis of 8 cases of sprue carefully studied roentgenologically, the small bowel changes occurring in chronic cases are given. The duodenum is wide and atonic, with complete absence of mucosal relief. The jejunum also is wide, with irregular slight contractions of the wall and absence of the normal mucosal pattern. In the lower jejunum and upper ileum there were hypertonic areas with strong contractions and coarse folds. The mucosal pattern consisted of an irregular, snowflake-like spotting. The ileum is hypotonic; the mucosal pattern is lacking and the contrast meal is delayed in transit.

In acute cases disturbances of tonicity, slowing of the progress of the meal, alterations in the peristaltic movements, especially in the ileum, and filling changes leading to a "torn-up" appearance were observed. The mucosal pattern lost its feathery character and the folds became flat and the distribution "blobby."

In general the changes in sprue are a loss of fat absorption and a severe functional injury to the mechanism of the small bowel. This leads to abnormalities of outline (segmentation), delayed passage of contrast media, irregular precipitation, and abnormal mucosal relief. LEWIS G. JACOBS, M.D.

Clinical and Roentgen Difficulties of Diagnosing High Small Bowel Carcinoma. Kurt Schmitt. München. med. Wchnschr. **88:** 556–559, May 9, 1941.

The author reports three cases of small bowel carcinoma in which a clinical diagnosis of other gastrointestinal tract diseases was made and makes the following observations.

(1) Small bowel carcinoma occurs occasionally, being most common in the duodenum. It may be found near the duodenojejunal juncture or in the first 15 to 100 cm. beyond. This is in contradiction to Saupe's belief that carcinoma was to be found only at the beginning or end of the small bowel.

(2) The three patients were 30, 39, and 43 years of age; two were male, one female.

(3) Symptoms were atypical, even those of bowel stenosis being chronic and of slow development.

(4) The general condition of the patients remained good; there was no cachexia.

(5) The presence of occult blood in the meat-free stools was the sole constant sign. Anemia was found in only one case.

(6) Differential diagnosis is difficult. In this series one case was first diagnosed as spastic colon, one as gallbladder disease, and the third as high intestinal obstruction.

(7) Roentgen diagnosis depends in large measure on clinical suspicion of the lesion. In two cases the lesion was overlooked; this is easily done on routine fluoroscopic examination. LEWIS G. JACOBS, M.D.

Primary Carcinoma of the Jejunum: A Case Report. W. Johnston Craig. Brit. J. Radiol. **14:** 210–212, June 1941.

A woman, aged forty-eight, complained of almost continuous abdominal pain below the right costal margin, for three months, which was not relieved by alkalies. The pain was sometimes colicky. Undigested food was occasionally vomited. There was no palpable tumor, but there were epigastric tenderness and a moderate anemia. On x-ray examination a narrowing was observed about two inches beyond the duodenojejunal junction. There was a small gastric residue. At operation an annular carcinoma was found.

The prognosis in carcinoma of the jejunum is poor. Metastasis occurs early. The average duration of life after operation is one year.

SYDNEY J. HAWLEY, M.D.

Regional Lymphatic Metastases of Carcinoma of the Colon. Frederick A. Coller, Earle B. Kay, and Robert S. MacIntyre. Ann. Surg. **114:** 56–67, July 1941.

A study of regional lymphatic metastases was made in 46 cases of carcinoma of the colon. The lymph nodes were visualized for dissection after the method of Spalteholtz as modified by Gilchrist and David. Of the 46 cases, 60.87 per cent showed evidence of regional lymph node metastasis. The average number of nodes isolated was 52.07. In cases having node involvement the average number was 59.4; in specimens without metastatic involvement, 41.4. The relative incidence of metastasis in each half of the colon is: right colon 62.5; left colon, 60 per cent. The relative accuracy of this method of study is shown by the presentation of comparable observations by other writers.

The findings of Simpson and Mayo (Surg., Gynec. & Obst. **68:** 872–877, May 1939) are given in tabular form and a table is also presented showing the distribution of node metastases in the authors' series.

SERIES OF SIMPSON AND MAYO

Site of Tumor	No. of Cases	Cases with Metastasis
Rt. colon	28	14 (50.0%)
Transverse colon	15	6 (40.0%)
Descending colon	26	12 (46.2%)
Sigmoid colon	51	15 (29.4%)
Totals	120	47 (41.4%)

AUTHORS' SERIES

Site of Tumor	No. of Cases	Cases with Metastasis
Colon	4	3 (75.0%)
Ascending colon	4	2 (50.0%)
Hepatic flexure	3	1 (33.3%)
Transverse colon	9	7 (77.7%)
Splenic flexure	3	2 (66.6%)
Descending colon	3	2 (66.6%)
Sigmoid colon	20	11 (55.0%)
Totals	46	28 (60.87%)

Factors other than lymph node metastases which influence operability are extensive local infiltration, hematogenous metastases, and peritoneal implants. Over 93 per cent of the authors' cases had infiltrated

through the bowel wall and were a constant source of free peritoneal implantation.

The authors outline and discuss the lymphatic drainage of the colon and illustrate with line drawings the metastatic routes which growths in the various colonic segments follow. The lymphatic supply of the colon consists of three main systems: the intramural, intermediary, and lymphatic networks. The intramural system is further subdivided into 3 parts, the submucosal, intermuscular, and subserosal. Where the large intestine lacks continuous longitudinal musculature, the subserosal and intermuscular networks are the same. The lymph channels originate around the glands of Lieberkühn and empty into the submucosal network. This group communicates with like channels both above and below the lesion.

As lymph channels follow the course of blood vessels around the circumference of the colon, malignant growths of this organ are annular. The lymph passes from the intermuscular system through the intermediary channels to the extramural lymphatic system. This group is composed of lymph nodes and channels which are arranged about the blood vessels, the various lymphatic chains taking their names from the vessels which they accompany: (1) ileocolic, (2) right colic, (3) middle colic, (4) left colic, (5) inferior mesenteric chain. Along each chain are aggregations of nodes which are designated as epicolic, paracolic, intermediate, and the main group of nodes

The epicolic nodes are situated along the anterior and posterior surfaces of the colon; the paracolic nodes along the medial aspect of the large bowel near the vascular arcades and short terminal vessels which go out from the arcades; the intermediate nodes about halfway between the arcades and the origins of the ileocolic, colic, or sigmoidal branches. The main group is located around the proximal portion of these vessels at their origins.

The multiplicity of lymph channels draining the various parts of the colon explains the absence of contiguous lymph node involvement. The metastatic embolus may travel by channels which circumvent the intervening nodes and carry the malignant cells to the more distant nodes, allowing some of the nodes nearer the site of the lesion to escape involvement. Lymph nodes act as barriers to filter out neoplastic cells. If the cancer cells remain viable a new malignant focus develops. This tends to block the lymph channel, which is then filled and distended with lymphocytes. The flow of lymph ceases and other neoplastic foci are established along the course of the channel. The direction of lymph flow determines the direction of metastasis. If the lymph channels become plugged, the lymph will find unobstructed channels and malignant emboli will spread along these.

An excellent diagram of the lymphatic supply of the colon is presented and the lines of incision for proper surgical removal of growths situated in the various segments of the colon are shown.

The presence or absence of regional lymph node metastases was correlated with the age of the patient, sex, duration of symptoms, gross type of neoplasm, size, circumferential extent, depth of infiltration, microscopic type, and degree of cellular infiltration.

Age and Metastasis: The average age of patients with metastases was 50.9 years; the average age of those without metastases 59.1 years. Prognosis was less favorable in the younger age groups.

Duration and Metastasis: There was an average duration of symptoms of 10.4 months in those cases with regional lymph node metastases, as compared to an average duration of 11.5 months in those without. Patients with symptoms of long duration, who are still operable, often have the best prognosis, since in these cases the neoplasm is of low-grade malignancy and grows slowly.

Gross Types and Metastasis: Of polypoid neoplasms 57.5 showed evidence of metastasis; of sessile neoplasms 83.3 per cent.

Size and Metastasis: The average size of lesions in the right side of the colon with metastases was 32.75 sq. cm., whereas the average size of lesions without metastases was 39.75 sq. cm. The average for lesions of the left colon with metastases was 22.11 sq. cm. in comparison to 31.73 sq. cm. in those without metastases. Neoplasms in which node involvement was found were thus smaller than those with no metastases, indicating that smaller neoplasms giving rise to symptoms were of a more malignant nature and metastasized earlier.

Circumferential Involvement and Metastasis: Because of the high incidence of involvement of the entire circumference of the bowel in this study, a correlation between partial annular involvement and metastases could not be made. Of the 3 cases which showed 25 to 50 per cent of circumferential involvement, only one had metastasized. The relation of complete annular involvement to incidence of metastasis is obvious from the authors' statistics.

Depth of Infiltration and Metastasis: No correlation between depth of infiltration and regional lymph node metastasis was found.

Degree of Cellular Differentiation and Metastasis: The percentage of metastases increased with the grade of malignancy. The figures for the various histologic types were as follows:

Histologic Type	No. of Cases	No. with Metastases
Papilliferous adenocarcinoma	8	3 (37.5%)
Adenocarcinoma (simplex)	29	18 (62.07%)
Adenocarcinoma mucosum	4	3 (75.%)
Medullary adenocarcinoma	5	4 (80.%)

HORACE C. JONES, M.D.

A Roentgen-Ray Aid in the Diagnosis of Acute Portal Thrombosis (Pylephlebitis). Anthony Bassler. Am. J. Roentgenol. **45:** 724–727, May 1941.

Three cases of acute portal thrombosis are presented to prove that valuable information may be gained by roentgen examination. In the roentgenograms it was noted that the stomach and duodenum emptied normally and the colon showed no delay beyond the first third of the transverse colon. The entire small intestine from the jejunum down was markedly slowed in its transit function to as late as twenty-four hours. The barium is distributed in mass collections with intervening empty areas (segmented). These collections appear as dense patches with no suggestion of valvulae conniventes or lumen formation. These findings are explained by the vessels involved. In these three cases there was early enlargement of the spleen.

S. M. ATKINS, M. D.

THE SKELETAL SYSTEM

Paget's Disease of Bone (Osteitis Deformans). B. H. Nichols and J. R. Raines. Cleveland Clinic Quarterly **8:** 139, July 1941.

Paget's disease of bone is more frequently recognized now than formerly. In the group of 48 cases reviewed here the average age at discovery was sixty years, the oldest patient being eighty-eight and the youngest thirty-two years of age. In the past, the skull and femur were thought to be the most frequent sites,

but with wider study the spine and pelvis have assumed the first place.

Pain in the back and down the legs occurred in some patients with spine involvement; anterior bowing of the legs was the complaint in the presence of tibial involvement, and skull involvement was sometimes accompanied by enlargement of the head.

The cause of Paget's disease is unknown but several theories have been suggested: fluoride poisoning, parathyroid dysfunction, dysfunction of the adrenal cortex, trauma, and a familial tendency.

Laboratory tests show the serum calcium to be at the upper limits of normal and the serum phosphorus to be near the upper normal figure. The only constant finding in this series was an elevated serum phosphatase activity. Recently acid phosphatase determinations in Paget's disease have been reported as normal in early and moderately advanced cases, and may be a good differential procedure in certain instances.

Pathologically, the process is primarily one of bone absorption with osteoporosis and vascular changes, followed by replacement with osteoid tissue. Early the bone is soft and it is then that deformity occurs. The trabeculae are coarse and the fragments of lamellar bone form an irregular mosaic, which is characteristic.

Radiologically there is first porosis followed by sclerosis, with increased bone size and loss of normal structure. The normal cortical shadow is lost and the cortex now appears thickened, irregular, more dense in some areas, and less in others. The marrow cavity is narrow and the trabeculations are accentuated. Fractures may occur and some areas have been known to become malignant. No cure is known.

J. B. McAneny, M.D.

Spontaneous Fracture of the Femoral Neck Following Roentgen-Ray Therapy over the Pelvis. D. Hight. J. Bone & Joint Surg. **23:** 676–681, July 1941.

A patient with carcinoma of the penis with inguinal metastasis was treated by roentgen irradiation, receiving 1600 r to each groin, 400 r per treatment, 10 × 15 cm. field, 200 kv., 0.5 Cu filtration, 50 cm. distance. Four months later he complained of pain, and films of the pelvis suggested a fracture of the left femoral neck. Four months after this the fracture was complete and showed no callus formation. The other femoral neck was also fractured at this time. The right femoral fracture healed but the left required surgical fixation, which gave the patient adequate support.

This is the first instance of spontaneous fracture of the femoral neck encountered by the author in a series of 1,084 patients receiving irradiation over the pelvis, a percentage of 0.09. Others have reported the incidence as 2.1 per cent and 2.8 per cent.

The author feels that one is not justified in the belief that radiation is the sole cause of the fracture, but that its administration in the presence of arteriosclerosis might precipitate an acute absorption of bone with resulting fracture. It is suggested that in pelvic irradiation, the fields be small and the femoral necks be avoided if possible. J. B. McAneny, M.D.

Examination of the Shoulder for Calcium Deposits. B. M. Bosworth. J. Bone & Joint Surg. **23:** 567, July 1941.

There is great difficulty at times in making a definite diagnosis of the presence or absence of calcification about the shoulder joint. This paper suggests as the most practical and efficient means of diagnosis fluoroscopy of the joints and spot-films made in the most advantageous position to show the lesion. In a series of over 6,000 patients this has been found to be the best means of examination.

Both shoulders should be studied fluoroscopically through full range of motion, with the patient standing. The cyst-like appearance of the greater tuberosity that sometimes occurs should not be mistaken for a pathological state.

A method of examining the shoulder with portable roentgen equipment is offered. Caution is urged against over-exposing either the patient or operator to excessive irradiation. It is believed better to have the examination made by one thoroughly familiar with the potential dangers of x-rays. J. B. McAneny, M.D.

Case of Bilateral Avulsion of the Anterior Inferior Iliac Spine. Willy Bachmann. Schweiz. med. Wchnschr. **71:** 721–722, June 7, 1941.

A recruit, 18 years of age, on running to accelerate the heart rate for a functional test, suddenly collapsed with severe bilateral lower abdominal pain. Tenderness in this region was found to be due to avulsion of the epiphyses of the anterior inferior spines of the ilium. As the rectus attaches here as well as at the hip joint, the avulsion was thought to be due to muscle pull. The patient made an uneventful recovery, but one month later, after a very slight trauma, suffered a displacement of the right radial epiphysis. The author believes this boy had an abnormal susceptibility to this form of injury. Lewis G. Jacobs, M.D.

The Temporomandibular Joint in Rheumatoid Arthritis. Theodore B. Bayles and Leslie A. Russell. J. A. M. A. **116:** 2842–2845, June 28, 1941.

Involvement of the temporomandibular joint occurs in more than half of all patients with rheumatoid arthritis. Pathologic processes in this joint resulting from malocclusion may simulate many neurologic and otologic disorders. Costen and others have shown that otic symptoms predominate in patients with edentulous mouths and that pain is most common in patients with natural malocclusion or malocclusion from loss of molar support on one side. The symptoms or signs referable to the ear resulting from malocclusion are local stuffiness, impaired hearing, herpes, tinnitus, and dull pain. Other symptoms described as resulting from malocclusion are headache and sinus pain; a burning sensation in the throat, tongue, and side of the nose; rarely decreased or increased saliva; herpes of the buccal mucosa; trismus.

The temporomandibular joint is ginglymo-arthrodial (hinge-sliding) in character. The combination of, a sliding hinge motion and a complete interarticular disk differentiates this joint from all others usually involved in rheumatoid arthritis. The course of the pathologic process here is no different from that in other joints so far as we know. Clinical, roentgenographic, and postmortem study are difficult, however, because of the anatomic location. Synovitis is probably the most important primary pathologic change. Proliferation of the synovium, periarticular edema, and hydrarthrosis may follow and produce local pain, tenderness, swelling, and irritative phenomena in the nerve supply to the synovium. Limitation of motion is usual, but complete ankylosis was not observed in the authors' series of 515 patients. They ascribe this to interposition of the disk. Their patients are divided into two groups, those with partial and those with considerable limitation of motion, *i.e.* with more and less than 5 mm. of opening power, respectively. Limitation of motion of the temporomandibular joint in patients under 15 leads to deformity of the jaw through hypoplasia of the mandible. In older patients, rheumatoid arthritis of this joint may lead to subluxation which, when severe, may cause the mandible to recede as much as one inch. This is especially true in patients confined to bed in the supine position, due to the pull of gravity.

The authors recognize three types of temporoman-

dibular involvement in arthritis: transitory, acute, and chronic.

The *transitory type* was found to be present in 8 per cent of patients with rheumatoid arthritis. Opening is limited to about 10 mm. for one to three days. Neuralgic discomfort about the side of the head and jaw is present. Complete rest of the closed jaw and application of heat give relief and the prognosis is good.

The *acute type* occurs in 20 per cent of patients with rheumatoid arthritis. The symptoms are more severe and eventually the pain becomes localized in the area of the joint. Limitation of motion, local pain (sometimes excruciating), warmth, and swelling make the diagnosis obvious. The course is from six to ten weeks. Physiologic rest is of paramount importance. The patient must be impressed with the importance of not stretching the jaw to see how he is progressing. After the muscle spasm and pain have subsided, gum-chewing exercises are indicated. The authors have always had good functional results, though a small amount of motion was lost by most of the patients.

When opening of the jaws is limited to less than 25 mm. for more than four months, the involvement is classed as *chronic*. This is found in 23 per cent of patients with rheumatoid arthritis. The larger group of patients with chronic involvement respond moderately well to treatment. Patients with chronic limitation of motion of a mechanical type are fewer in number, and in these strenuous stretching exercises and forcible wedging have been of value. In some cases resection of the neck of the mandibular condyle near its head, with insertion of a transplant of fascia lata in the area of the resected bone, must be resorted to. Careful, intensive, conservative treatment at the transitory, acute, and chronic "active" stages of the disease will prevent the serious complication of marked limitation of motion and make late plastic operation unnecessary. CLARENCE E. WEAVER, M.D.

Complete Roentgen Ray Studies of the Gastro-Intestinal Tract in 400 Arthritics. E. W. Spackman, T. F. Bach, C. W. Scull, and R. Pemberton. Am. J. M. Sc. **202:** 68–77, July 1941.

Complete roentgenographic studies of the gastro-intestinal tract of 400 arthritic patients and 100 normal persons were compared. This analysis was undertaken because it was felt that focal infection did not account for the syndrome of arthritis, and that many other, particularly nutritional, factors played contributory rôles. Special attention was paid to size, shape, position, and function of the various organs.

Sixty per cent of the arthritic patients showed deviations from normal structure and function in the stomach, gallbladder, or small intestine. The most nearly characteristic complex was found in the colon, which exhibited ptosis, dilatation, or atony in 80 per cent of the cases. No one of these deviations is typical of rheumatoid disorders, but a combination of them constitutes a more or less definite pattern in severely ill arthritics. There was a tendency, in the course of the disease, for the ileal stasis and configuration of the colon to become more marked. This is not considered pathognomonic for arthritis, but occurs with chronic diseases of many kinds. As these patients undergo convalescence, striking improvement in configuration and function occurs.

These data indicate what clinical experience has long borne out: that arthritics as a group suffer from dysfunction of the lower bowel and elsewhere, which is susceptible to betterment. The necessary measures are included in a comprehensive plan of therapy which considers all aspects of the problem and of the patient. BENJAMIN COPLEMAN, M.D.

Analytical Study of Bone and Joint Lesions in Relation to Chronic Pulmonary Tuberculosis. E. Rosencrantz, A. Piscitella, and F. C. Bost. J. Bone & Joint Surg. **23:** 628–638, July 1941.

The mortality rates usually given for tuberculosis of the bones and joints are at such great variance with the experience of the authors that a study was made of 4,252 cases from a general tuberculosis hospital. One hundred and sixty patients (3.76 per cent) had bone or joint tuberculosis, the lesions totalling 203. The greatest incidence of bone and joint lesions, as of pulmonary tuberculosis, occurred between the ages of fifteen and thirty-five years, supporting the contention that these lesions are secondary to some other tuberculous focus. The yellow and black races showed a mortality of 70 per cent compared to 43 per cent for whites. There were 42 patients without clinical evidence of pulmonary tuberculosis but 34 of these had tuberculosis of some other organ besides bone or joint.

Study of the end-results was discouraging, showing 17 per cent well; 21 per cent improved; 13 per cent unimproved; and 49 per cent dead. In the non-pulmonary group 45 per cent died, which was not unexpected, as all had multiple lesions. In the pulmonary group half the patients died, the rate corresponding to the stage of pulmonary tuberculosis. Of those patients with positive sputum, 79 per cent died or failed to improve. Of 72 patients treated surgically, 29 died, 6 were unimproved, 21 improved, and 16 well.

The study demonstrates the high death rate in bone and joint tuberculosis associated with pulmonary lesions, and indicates the necessity of a complete physical examination including laboratory work and chest roentgenograms in patients with tuberculous lesions of the skeletal system. J. B. MCANENY, M.D.

NIEMANN-PICK'S DISEASE

Niemann-Pick's Disease: A Report of Four Cases. Lawrence E. Maurer. Rocky Mountain M. J. **38:** 460–464, June 1941.

Niemann in 1914 first described a splenohepatomegalic condition in an 18-months-old child which he regarded as a clinical entity, differing from Gaucher's disease because of its early onset and rapid progress. Pick established this condition as a definite disease entity, the prominent features of which are onset at a very early age in children of Jewish parentage, feeding difficulties, frequent respiratory infections, bouts of fever, generalized brownish discoloration of the skin (especially the exposed surfaces), splenohepatomegaly, moderate anemia, moderate leukocytosis, vacuolization of the granulocytes, increase of the blood lipids, a cherry red spot in the macula in some cases, mental and physical retardation, and fatal termination from progressive cachexia or intercurrent infection before the age of two and a quarter years.

Up to the present time 58 cases of Niemann-Pick's disease have been reported, and of these 23 have been in the United States.

The author reports four cases, with necropsy findings in three. In the first case splenectomy was done, and twenty-five days later the child succumbed to post-operative complications. Autopsy revealed the characteristic foam cells of Niemann-Pick's disease in liver, lymph nodes, lung, adrenal glands, spleen, and bone marrow.

The second child died at the age of twenty-one months, the symptoms having been typical. In the third case roentgenograms of the skull and wrists were negative; death occurred at the age of six months. In the last case, also, roentgenograms showed negative findings in most of the skeleton. These last two children were brother and sister of Scotch-Irish parentage and at autopsy both showed an identical endocarditis.

Sixteen of the 23 cases reported in the United States were in children of Jewish parentage.

As to pathology, grossly the disease presents quite a constant picture. The spleen and liver are enlarged and on cut section are of a homogeneous butter-yellow color. The lungs show yellow mottling and the lymph nodes and adrenals may show the same yellow hue. The characteristic histopathological finding is the so-called foam cell, a large pale cell having a finely vacuolated or honeycombed cytoplasm. The foam cells are found in the liver, spleen, thymus, medulla of the adrenals, lymph nodes, alveoli of the lungs, and the bone marrow. Microchemically the foam cells do not stain positively for iron as do the cells found in Gaucher's disease.

The differential diagnosis must include Gaucher's disease, Hanot's cirrhosis, von Jaksch's anemia, congenital hemolytic icterus, congenital syphilis, and histoplasmosis. The author includes a bibliography of 31 references. PERCY J. DELANO, M.D.

RADIOTHERAPY

MALIGNANT TUMORS

Preliminary Observations on the Quantitative Examination of Human Biopsy Material Taken from Irradiated Carcinomata. A. Glücksmann. Brit. J. Radiol. **14:** 187–198, June 1941.

Biopsies from human basal-cell and squamous-cell epithelioma were studied. A preliminary biopsy was made, and tissue was subsequently removed from the growing edge at increasing intervals after irradiation. All the cells in selected areas were counted and classified as either mitotic, differentiating, resting, or degenerating cells.

Irradiation caused a reduction in the dividing cells in every instance, although sometimes this was only temporary. In some instances the number fell to zero. There was an increase in the number of abnormal mitotic figures. In successfully treated tumors the mitotic count ultimately disappears. A return of mitotic activity is of serious import.

Degenerating cells increased in number, usually after mitosis reached a minimum. There is a temporary fall in the degenerate cell count immediately after irradiation, indicating that the irradiation delays or prevents mitosis, and hence cuts off the supply of degenerating cells. In later periods the degenerating cell count may be increased further, indicating the breakdown of differentiating cells.

In nearly all cases there was a reduction of the number of resting cells. This rate varies widely in the different tumors.

In most instances of squamous-cell carcinoma there was an increase in the differentiating cell count following irradiation. This rise corresponds to the fall in the resting cell count. This relation is numerical as long as there is no degeneration.

An interesting effect of radiation in some tumors is the development of large cells. These occur among the differentiating cells. These large cells do not appear in tumors in which irradiation fails to alter the ratio of resting to differentiating cells, nor in basal-cell tumors.

This study indicates that malignant cells and normal cells react to irradiation in the same way, the difference being one of degree. This type of study provides a means of evaluating the response in relation to different methods of treatment, and the significance of such factors as time, intensity, and wavelength.

SYDNEY J. HAWLEY, M.D.

End-Results of Therapy of Epithelioma of the Skin. Shields Warren and C. R. Lulenski. Arch. Dermat. & Syph. **44:** 37–42, July 1941.

Healing of a primary epithelioma of the skin should not be taken as the criterion of cure, according to the authors, who followed two groups totalling 451 cases for two and five years.

The larger the lesion at the start of treatment, the greater the percentage of failure. Thus there were only 9 per cent of failures in epitheliomas measuring 1 cm. or less in diameter, while treatment failed in 65 per cent of those measuring over 5 cm. Almost half of the lesions that recurred did so more than two years after treatment.

In the series reported it appears that surgical excision gave better end-results than either x-ray or radon.

JOSEPH T. DANZER, M.D.

Carcinoma of the Female Breast. S. C. Graves. New England J. Med. **225:** 57–61, July 10, 1941.

This is a review of the results obtained with mastectomy in 376 cases of carcinoma of the breast. At times x-ray therapy was added. At five years 138 or 36.7 per cent of the patients were alive; at ten years 16.6 per cent, and at fifteen years 8.9 per cent. Twelve patients with recurrences were living between ten and fifteen years, and 4 patients died of the disease after fifteen years.

Radical mastectomy was done in 284 patients, of whom 159 had axillary metastases. Simple mastectomy was performed on 83 patients, because of the advanced state of the disease.

Comparison of various groups from 1900 to 1934 shows an increased survival percentage. From 1900 to 1919, 31; 1920 to 1924, 38; from 1925 to 1929, 39; and from 1930 to 1934, 44 per cent.

Roentgen therapy was added in 1918. It was administered in an admittedly irregular manner until 1929, when a more regular procedure was followed. It is believed that irradiation is best done postoperatively and that the best results are obtained in advanced cases, although radiotherapy is advised for all cases.

Twenty-one patients not previously irradiated were treated for recurrences. Their average length of life was only two years and only one patient survived five years, eventually to die of the disease.

J. B. MCANENY, M.D.

Metastasis of Primary Carcinoma of the Breast, with Special Reference to Spleen, Adrenal Glands, and Ovaries. Otto Saphir and Morris L. Parker. Arch. Surg. **42:** 1003–1018, June 1941.

A report of 43 cases, all of which came to autopsy, in which a histologic search of the organs for metastatic deposits from a primary breast cancer was made. Table 2 of the article, summarizing the results, is reproduced here.

The most common location was the lung (involved 28 times), with the liver (24), adrenal (19), spleen (10), pleura (10) and ovary (7), following in order. (Studies of the bones were limited, as were those of the brain and spinal cord, as indicated in the table.) This is not in agreement with the older texts, but does correspond to the recent figures of Warren and Witham (Surg., Gynec., & Obst. **57:** 81, 1933). The frequent involvement of the spleen lends little credibility to the supposed immunity of this organ. In only 3 patients were no metastases found.

The fate of patients treated and not treated with ir-

Table 2: Frequency of Metastasis in Various Organs and Structures

	Cases		Cases
Organs involved		Bones†	
Lungs	28	Clavicle	1
Liver	24	Sternum	4
Spleen	10	Ribs	7
Kidneys	6	Spinal column	11
Adrenals	19	Femur	3
Pancreas	5	Pelvis	7
Ovaries	7	Skull	3
Opposite breast	5		
Cerebrum*	4	Unusual Locations	
Spinal cord*	1	Broad ligament	1
Diaphragm	6	Uterus	2
Pericardium	9	Cervix	2
Pleura	10	Pouch of Douglas	1
Peritoneum	4	Intestinal wall	1
		Gallbladder	2
		Superior vena cava	2
		Thyroid	1
Lymph Nodes		Myocardium	1
Axillary	12	Gastro-intestinal tract	3
Supraclavicular	3	Trachea	1
Infraclavicular	2	Hypopharynx	1
Mediastinal	13	Intercostal muscles	1
Peritoneal	11	Scalp	1
Retroperitoneal	13	Skin	2
Inguinal	3		

* The brain and spinal cord were examined only when there were clinical symptoms referable to their involvement.

† As a rule, only those bones were examined that could be made visible by the routine method of opening the body.

radiation was the same in the cases studied. The series is too small, however, to allow conclusions to be drawn from this. Studies of the various pathologic types of carcinoma showed that no one of them was more malignant than another.

[Owing to the special nature of the material and the type of investigation, the figures reported must be markedly biased when compared with clinical studies. Conclusions to be applied to the living patient must therefore be drawn with extreme caution.—L. G. J.]

LEWIS G. JACOBS, M.D.

Carcinoma of the Fundus of the Uterus. G. V. Brindley. Ann. Surg. **114:** 90–99, July 1941.

Surgery, irradiation, and a combination of the two methods have been used in the treatment of carcinoma of the uterine fundus. Opinions vary as to the most effective procedure. Because of this diversity of views, the writer made a study of a series of 92 cases with the particular purpose of evaluation of the end-results of treatment.

The incidence of carcinoma of the fundus as compared with carcinoma of the cervix is as 1 to 6. The author also has found 6 carcinomata of the fundus to 1 sarcoma. These findings are essentially the same as those of other investigators.

The etiology of fundal carcinoma is obscure. It is often associated with endometrial hyperplasia or functional abnormalities of the reproductive organs. Counseller believes that this type of cancer is related to ovarian hormones. Herrell thinks that the unopposed action of estrin plus the necessary genetic factor for cancer development may be an etiological factor. Eighty-seven of the 92 patients in the author's series were married. Parity plays no rôle. Fibroid tumors are considered to be of little etiologic consequence but fundal cancer may develop from endometrial polyps. Thirteen of the patients in the author's series had uterine polyps.

Cancer of the fundus tends to occur in women who have a late menopause; 70.6 per cent of those in the author's series developed symptoms before the menopause. The average menopausal age of the patients who had cancer beginning after the climacterium was forty-nine. The average age in a series of cases reported by Healy and Brown was fifty-five years. Of Counseller's patients, 90 per cent were over forty-five years of age. Seventy-three of the 92 cases reported in the present communication occurred after the age of fifty-five.

The cardinal signs and symptoms are metrorrhagia, menorrhagia, vaginal discharge, and pain. The most significant sign is vaginal bleeding. Norris and Dunne found it as the first sign in 80.5 per cent of their series. Pratt observed gross or microscopic bleeding in all his cases. Abnormal vaginal bleeding was the symptom of first importance in 93.5 of the cases in the author's series. It should be emphasized that the amount of blood may be small and bleeding may occur at long, irregular intervals. The profuse bleeding seen in benign uterine conditions does not occur in this disease. Patients usually disregard the small amount of blood and fail to consult a physician. Many patients with uterine carcinoma give histories of a brownish watery discharge of an irritating nature.

Pain occurs in approximately one-third of the cases. It is rather dull in type; aching, heaviness, or discomfort may be all that is mentioned. Severe pain usually means that metastasis has occurred. As a corollary to this, patients who complain of pain have a poorer prognosis than those who do not. The average duration of symptoms in this series before treatment was begun was ten months. The difficulty in estimating accurately the onset of the disease is recognized.

A careful physical examination is essential for accurate diagnosis and a satisfactory plan of therapy. Factors which influence the type of treatment are the size, shape, irregularity, and mobility of the uterus. A physical examination may reveal involvement of the cervix, or a polyp may be seen protruding from the external os. Blood may be seen coming from the cervix and infrequently a metastatic implant will be seen in the vaginal mucosa. Physical examination will be negative in about one-third of the cases. The uterus was moderately enlarged and less than a depth of 6 inches in 51 of the 92 cases in the author's series; 10 patients showed pronounced uterine enlargement.

Diagnostic curettage and examination of the uterine scrapings by a competent pathologist is the one diagnostic procedure. Fibroids are associated with fundal carcinoma in from 25 to 35 per cent of the cases. No etiologic connection is believed to exist, but the presence of fibroids increases the difficulty of making an accurate diagnosis because the symptoms of the malignant growth are obscured. Curettings from all uterine fibromyomata should be carefully studied and at operation all uteri should be opened and examined by a pathologist. Of the 92 patients considered here, 9 were operated on for a benign condition and when the uterus was opened carcinoma of the fundus was found.

The uterine anatomy and the scanty lymph supply are conducive to slow dissemination. This is a matter of months, sometimes of years. Of the cases constituting the author's series, 46 were of grade II. The relationship of grade of malignancy to age is shown in the accompanying table. The growths of low-grade malignancy tend to occur in the younger group.

Most of the patients in the author's series were treated by irradiation or a combination of irradiation and surgery. The order of procedure usually was an exploratory curettage for all patients with suggestive

history, followed by examination of a frozen section of the scrapings by a pathologist. If cancer was found, radium treatment was given and a panhysterectomy was done six to eight weeks later, if the case was favorable for this procedure. If irradiation alone was used, roentgen therapy was begun two to eight weeks after insertion of radium, from 1 to 3 series being given at two-month intervals. When postoperative roentgen therapy was instituted, the first series was begun three to eight weeks following operation.

Grade	Average Age	Pre-menopause	Post-menopause
I	48	6	6
II	53	13	32
III	58	3	24
IV	59	0	3

Thirty-one of the 92 patients were treated by radium without surgery; 41.9 per cent survived from five to thirteen years; 51.8 per cent are known to have died within five years, 2 of intercurrent disease. The patients treated by radium who lived five years or more received an average dose of 3,500 mg. hours. Those who lived less than five years following radium treatment received an average of 3,800 mg. element hours.

Of 24 patients treated more than five years ago by radium with subsequent hysterectomy, followed by roentgen therapy, 79.1 per cent are alive and free from disease. The highest percentage of cures has been obtained by this method. The author believes that a study of his series indicates that preliminary intrauterine irradiation followed by a panhysterectomy is the procedure of choice, if the disease is limited to the uterus and the patient is a reasonably good risk.

Fifty-five per cent of uteri removed following radium application showed the presence of cancer cells. The average dose of radium for those uteri in which no cancer cells were found was 2,600 mg. element hours and for those uteri in which cancer cells were found 2,500 mg. hours. Fifteen patients in whose uteri cancer cells were found at hysterectomy following irradiation were followed. Of these, 73.3 per cent are alive and well after five years. Nine patients whose uteri were cancer-free have a survival percentage of 88.8 per cent for the five-year period. Dosage now is from 3,000–4,500 mg. element hours with subsequent surgery. In cases treated by irradiation exclusively 6,000 mg. element hours are given.

Certain technical factors militate against a uniformly adequate dosage. Among them are size and shape of the uterus and uterine cavity. Regardless of these difficulties irradiation has won a recognized place in the treatment of cancer of the uterine fundus.

Preoperative irradiation should be of value for 5 reasons: (1) it should decrease possibility of dissemination when surgery is done; (2) it may destroy malignant tissue which is beyond the scope of surgical removal; (3) it should definitely decrease the probability of contamination of the field with carcinoma cells; (4) it decreases likelihood of vaginal recurrence; (5) it permits the administration of larger doses to the vaginal vault, as the body of the uterus acts as a screen. Apparently preoperative irradiation did not make the surgical procedure more difficult in the cases reported here.

When the uterus is moderately enlarged parametrial involvement by the cancerous growth has probably already occurred and these cases are preferably treated by irradiation alone. The rate of curability is inversely proportional to the size of the uterus. Curability is also definitely modified by the degree of malignancy. The percentage of cures was 87.5 for Grade I lesions; 57.4 for Grade II; 52.6 for Grade III. The one patient in this series with a Grade IV lesion followed for five years survived.

Ten of the cases in the series here reported were treated for a supposedly benign lesion for an average of 7.7 years before the true nature of the condition was determined at operation.

The author corroborates the observation of Burnam that there is a distinct tendency on the part of these patients to develop cancer of an entirely different type in another part of the body.

HORACE C. JONES, M.D.

New Method for the Application of Radium within the Uterine Cavity, with Particular Reference to Carcinoma of the Fundus. George E. Pfahler. Pennsylvania M. J. **44:** 1118–1123, June 1941.

In many cases of carcinoma of the body of the uterus we have to deal with an enlarged and irregular uterine cavity. An ordinary radium capsule inserted into this cavity, according to Schmitz, "may and does shift its position as much as 2.75 cm." Because of this shifting it is possible that one portion of the uterus may receive as little as 25 per cent of the radiation delivered to another port.

The author has tried to produce a more even distribution of radiation in the uterine cavity by inserting at the time of diagnostic curettage a sufficient number of 10-milligram radium capsules to fill the cavity entirely. This procedure allows the use of from 8 to 15 capsules having 1 mm. of platinum and 1 mm. of gold filter, which is equal to 4 mm. of lead. The capsules are left in place from twenty-four to forty-eight hours according to the number used, and a total dose of about 3,600 milligram hours is given.

JOSEPH T. DANZER, M.D.

Treatment of Chronic Leukemia by Small Dose Roentgen Ray Technic. Andrew H. Dowdy and John S. Lawrence. J. A. M. A. **116:** 2827–2831, June 28, 1941.

Despite the fact that roentgen therapy is the method of choice in leukemia, there is great diversity of opinion as to the type of application. Some advocate local (regional) treatment to the spleen or enlarged lymph nodes. Others irradiate the chest or trunk. Irradiation of the entire body either by the teleroentgen technic or the Heublein method is used by others. Dosage and frequency of treatments are subject to wide variations. Many advocate small doses, but there is no general agreement as to what constitutes a small dose. Irradiation of the whole body is not without danger and is not applicable in all instances.

The authors stress "the individualization of the patient and the numerically small individual and total dose of roentgen rays required in roentgens (measured in air) to bring about a satisfactory response." They believe irradiation of the circulating blood is of primary importance. Therefore irradiation over the precordium, the pulmonic fields, the spleen, or the liver would show a greater response than would irradiation over enlarged lymph nodes.

In addition to regional treatment of spleen, liver, and the various involved lymph nodes, the authors also use a quadrant technic in which the trunk is divided into the following areas: (1) the anterior part of the chest, and (2) of the abdomen, and (3) the posterior part of the chest, and (4) of the abdomen. The purpose of the study was to produce a technic which would give a gradual reduction in the total white blood cell count, with the least amount of irradiation and without any feeling of malaise or systemic reaction on the part of the patient, such as increased toxicity. The comfort of the patient was much greater with small (50 roentgens)

doses than with large doses (100 to 150 roentgens) per treatment. Leukemia with leukopenia, if not a result of therapy, is no contraindication to roentgen therapy, but here the individual dose must be small and the regional technic used. In general, persons with a high percentage of adult white cells, without anemia and with a normal count of platelets, respond best. The technical factors are: 200 kv., 25 ma., a 50 cm. skin-target distance and a filter of 0.5 mm. copper and 1 mm. aluminum.

With a new patient it is important to establish the tolerance and susceptibility of the disease to irradiation. Local irradiation to the spleen or enlarged nodes with an initial dose of 25 to 50 roentgens (in air) applied to an area 10 × 15 cm. to 15 × 15 cm. may be used to initiate the treatments. A temporary increase in the total white cell count may result with these small doses. If after three or four such daily treatments there has been no reduction in the total count and no systemic reactions, the dose may be increased or one may change to the quadrant technic. It is seldom, if ever, necessary to go beyond a daily dose of 75 roentgens with either method. With the local technic treatments should be given daily. With quadrant technic and doses of 50 to 75 roentgens, the frequency may depend on the patient's geographic location and economic status. A count of white cells should precede each treatment. The reduction should be gradual. In leukemia with leukopenia, local technic only is advised with the daily dose not exceeding 50 roentgens.

In the past three years, the authors have treated 20 patients with chronic leukemia, with individual small doses of roentgen rays by the local or quadrant technic or by a combination of the two. Life expectancy is not altered by these smaller doses but there has been an increased degree of comfort in comparison with the higher individual doses. Patients are practically free from nausea and vomiting. Their convalescence is more rapid after a series of treatments. Most patients required two series of treatments.

The authors believe that persons with chronic leukemia may be overirradiated, and to do this is to court disaster. Some patients are more susceptible to the unfavorable reactions following roentgen therapy than others. The sensitivity of the white blood cells varies from person to person and at different times in the same person. Consequently, the total count is no criterion as to the size of the single dose or the total amount of irradiation required for any one series.

The conclusion is reached that chronic leukemia will respond satisfactorily to much smaller individual and total doses of roentgen rays than those commonly employed. The highest total dose given in the cases reported here was 750 roentgens. The authors endeavor to secure the maximum improvement and the minimum discomfort with the smallest amount of radiation. Any individual dose which produces nausea or a feeling of increased toxicity is likely to be an excessive dose. CLARENCE E. WEAVER, M.D.

Primary Malignant Tumors of Bone. Henry W. Meyerding and Jorge E. Valls. J. A. M. A. **117:** 238–243, July 26, 1941.

The authors have studied 424 primary malignant tumors of bone encountered at the Mayo Clinic during the past quarter century. For accuracy they have separated those cases in which surgical operation permitted microscopic diagnosis from those in which the diagnosis was based on clinical and roentgenographic examinations. It is their practice to apply a tourniquet whenever possible and to remove a small piece of tissue for microscopic corroboration of the clinical and roentgenologic diagnosis before carrying out radical surgical measures.

Osteogenic Sarcoma: An osteogenic sarcoma is a malignant tumor which develops from tissue that is predestined to form bone-producing cells. This class includes osteosarcomas, chondrosarcomas, osteochondrosarcomas, osteochondrofibrosarcomas, and osteochondrofibromyxosarcomas. Periosteal fibrosarcomas probably arise from the outer portion of the periosteum or neighboring tissue. Periosteal osteogenic sarcoma apparently originates from the corticoperiosteal tissue and produces true bone.

Of the total series of cases of primary malignant tumor of bone, 50.9 per cent were osteogenic sarcoma. The largest number of patients, about 40 per cent, were between the ages of ten and twenty, and more than 50 per cent were less than thirty. In 44.4 per cent there was a history of trauma. Nearly 35 per cent of these tumors occurred in the femur, 17.6 per cent in the tibia and 9.3 per cent in the ilium; 22.2 per cent appeared in the region of the knee joint. Expectancy of life and results of treatment are influenced by the grade of malignancy.

Since 1920 the use of radiotherapy in selected cases has increased. The tendency has been to use multiple converging beams, the quality varying according to the mass of tissue in which the tumor is situated. Preoperative irradiation has not been tried. By force of circumstances, treatment has been almost entirely postoperative. Of 29 patients concerning whom diagnosis was made from clinical and roentgenologic examinations, 28 received irradiation or irradiation and Coley's toxins combined; no surgical treatment was employed. Of the 27 who were traced, only 2 lived more than three years and none survived five years. Two-thirds died of metastasis in less than one year. A slight advantage in survival in favor of patients who received Coley's toxins was noted. The number so treated was small, however, and it is difficult to evaluate the significance of this advantage. Biopsy and co-operation of a skilled pathologist are of inestimable value in clearing up the question of diagnosis; furthermore, grading of the degree of malignancy may alter the decision as to the type of treatment and prognosis.

The percentage of five-year cures among traced patients who were treated by radiation after biopsy was 9.1. Experience to date has indicated that osteogenic sarcoma is inadequately responsive to this form of treatment. Excision was done in some cases when the degree of malignancy was low and the tumor was so situated as to make amputation impossible or when the patient refused a more radical procedure. Forty-four patients were so treated with or without irradiation or administration of Coley's toxins. Of these, 15 lived five years or more. The five-year survival rate after amputation was 24.7 per cent. The site of amputation should be well away from the tumor. When the malignant condition was of grade 1 amputation was never employed.

Osteogenic sarcomas as a group are highly resistant to irradiation; excision and amputation appear to be more reliable. The five-year survival rate for surgery was 23.4 per cent. There was no five-year survival among those patients on whom non-surgical treatment was employed.

Fibrosarcoma accounted for 9 per cent of the 424 primary malignant tumors being studied; 60.5 per cent of the patients were males and 60.5 per cent were less than thirty years old. The femur was involved in 34.2 per cent and the tibia in 15.8 per cent. The tumor was around the knee joint in 50 per cent. In tumors of high grades of malignancy amputation was advised whenever possible. Some tumors of grade 1 or 2 were excised. Of the traced patients treated with irradiation, 16.7 per cent survived five years or more. Of those treated by excision together with irradiation, 25 per cent survived five or more years. Forty per cent of those treated by amputation, with or without irradiation, lived at least five years.

Ewing's tumor, or endothelioma of the bone, is now widely accepted as an entity. It is often confused clinically and roentgenologically with osteomyelitis, but gives a characteristic response to irradiation. It usually occurs near the middle of the shaft of a long bone, in a bone of the pelvis, or in the scapula. When the periosteum is reached, the defensive reaction results in the formation of layers of new bone, producing an "onion-skin" appearance. Metastasis to regional lymph nodes and lungs may occur early; later other bones, the brain, or the viscera may be involved. Endotheliomas are purely osteolytic tumors. Clinically the onset is insidious, with vague, fleeting, aching pains, usually more severe at night. Chills and fever occur, and an erroneous diagnosis of osteomyelitis may be made. In the long bones roentgenologic study usually shows diffuse involvement of the shaft. There is often a moth-eaten appearance and the laminated onion-skin appearance is visible in the periosteal region.

In the present series, which numbered 114, 71.9 per cent of the tumors occurred in males; 66.8 per cent of the patients were under thirty years of age; 61.4 per cent of the cases involved the extremities. The femur was involved in 26.3 per cent.

Since 1922 increasing reliance has been placed on the radiotherapeutic test and on treatment by irradiation. The use of multiple converging beams has become the method of choice. Of patients traced over a period of five years after treatment with roentgen rays 37.5 per cent were living. Of those from whom only a specimen for biopsy was taken, and who were traced for five years, none was living. Amputation, alone or combined with irradiation or use of Coley's toxins, or with both of these adjunct measures, was followed by survival for five years of 24.2 per cent of traced patients.

Multiple Myeloma: The clinical picture of multiple myeloma is vague. Rheumatic or neuritic pain is an early symptom. Later there are weakness, loss of weight, and anemia. Bence-Jones protein is found in the urine in a large percentage of cases. A large number of the patients have passed forty years of age. A distinctive feature of these tumors is their multiplicity and their simultaneous occurrence in the bone marrow, especially in the spinal column, sternum, ribs, skull, and clavicles.

Forty-one of 424 primary malignant bone tumors were multiple myelomas; 75.6 per cent were in males, and 73.2 per cent in patients between the ages of forty and seventy. More than half of the tumors were recognized as multiple at the time of the original diagnosis. Treatment proved of little avail.

Giant-Cell Sarcoma (Malignant): Malignant giant-cell sarcomas accounted for only 1.6 per cent of the series. All patients were between ten and forty. The femur was involved in the majority of cases. Five of a total of 7 patients were treated by amputation followed by irradiation; a five-year survival of 83.3 per cent was recorded. These malignant giant-cell tumors are recognizable as such only on microscopic study.

Summary: Reviewing this entire series, it is noted that more than two-thirds (68.6 per cent) of the patients were males; 5.7 per cent of the total were less than ten years of age. The largest percentage of patients were between ten and nineteen years of age, namely 133 (31.4 per cent); 58.8 per cent were under thirty.

The femur, which was the bone most commonly affected, was the site of the tumor in 124 cases (29.3 per cent). Of all the tumors, 62.8 per cent were in the extremities. The authors do not believe that trauma is the etiologic factor in these tumors but point out that a positive history of trauma was obtained in 40.6 per cent.

In slightly more than a third of the cases amputation was performed; in about a fifth, excision; after these radical surgical procedures irradiation, with or without the administration of Coley's toxins, was carried out. In a fourth of the cases biopsy and irradiation were employed; in the majority of the remainder treatment was by irradiation only. Of those patients who were traced for five years after the first treatment, 22.9 per cent of those who received surgical treatment had survived; of those whose diagnosis and treatment was carried on without surgical measures, 9.1 per cent survived.

Roentgen rays are invaluable in diagnosis, prognosis, and treatment of certain types of tumors, especially Ewing tumors. The authors are convinced that surgical operation offers the best method of treatment for the majority of primary malignant tumors of bone.

CLARENCE E. WEAVER, M.D.

NON-MALIGNANT CONDITIONS

Failures Following Treatment by Irradiation of Cases of Benign Uterine Bleeding and Fibromyoma. James A. Corscaden. Am. J. Roentgenol. **45:** 661–675, 1941.

The author studied a series of 733 cases of uterine bleeding or myoma of the uterus in which the immediate post-irradiation condition was recorded and progress was followed for an average of eight years. These include all types of myoma except those complicated by apparent adnexal disease, those which showed signs of acute degeneration, and those in which the submucous tumor was pedunculated.

Bleeding was controlled in 98.1 per cent. Failure to control bleeding seems in most instances to have been due to underdosage. Dysmenorrhea, whether primary or the result of changes in the uterus or adnexal disease, always ceased when the periods were terminated. Headache coincident with the menses was relieved by the establishment of the menopause. As to reduction of uterine size, the larger the uterus the greater was the percentage of failure; 94 per cent were satisfactorily reduced when no larger than a five months' pregnancy; only 40 per cent when larger than a six months' pregnancy. Although infection of the myoma is generally regarded as a contraindication to radiation therapy, nevertheless in the 730 cases treated, where some must have been infected, only 4 have shown signs of infection following therapy. In fact, in certain cases of pelvic inflammation complicating myoma small divided doses will accomplish the sterilization and possibly have some beneficial effect on the inflammation.

The younger the patient the higher the dose necessary for sterilization. Two to three months is usually required. Six hundred roentgens anteriorly and posteriorly—200 kv., 5 mm. Cu filter, 50 cm. distance and 15 × 20 cm. portal—will sterilize most women over the age of thirty. Radium was applied in 25 or 50 mg. tubes filtered by 0.5 or 1.0 mm. of platinum surrounded by a 1.0 mm. tube of rubber. This was inserted into the fundus of the uterine cavity. Of women twenty-five to thirty-eight years of age receiving 1,800 mg.-hr., 4.2 per cent required further irradiation.

S. M. ATKINS, M.D.

DOSAGE AND TECHNIC

Medical Significance of Newer Developments in Radiation Physics and Technic. J. H. Müller. Schweiz. med. Wchnschr. **71:** 796–799, June 28, 1941.

An incomplete review of recent physical advances, based principally on articles published in the recent American literature by Compton, Stone, and Van de Graaf. After a consideration of some of the reported effects of roentgen and gamma radiation, the author concludes that about half a million volts is the optimum for practical therapy. Corpuscular irradiation is considered; electron therapy is dismissed as impractical at present because of the difficulty of obtaining an adequate depth dose. Some of the larger atomic particles that have been discovered would require

energies of the order of 100,000,000 volts to obtain a therapeutically useful radiation. Neutrons are the most promising. They have extreme penetration for heavy substances, but are stopped by those like water whose atomic mass is of the same order of magnitude as that of the neutron. The ionization so produced is much more intense than that produced by the wave radiations.

Brief descriptions of the canal ray tube and of the cyclotron are given. Artificial radioactivity is briefly discussed, emphasis being placed on the short life of such preparations, a fact which reduces the danger of late effects, and on the immediate preparation of gamma-radioactive applicators for local use.

LEWIS G. JACOBS, M.D.

Physical Investigations with 140 kVp Radiation. L. F. Lamerton. Brit. J. Radiol. **14:** 199–205, June 1941.

As little physical investigation has been done with radiation at 140 kv.p., the author has studied the absorption curve in copper, the variation in percentage depth dose with filtration, the dosage rate in air with fields of various dimensions, the percentage of back-scatter with varying fields, the depth dose along the central ray for different size fields and different target distances, and the amount of stray radiation near the tube. Isodose curves for four different field sizes are given.

SYDNEY J. HAWLEY, M.D.

Inverse Square Law Errors in Gamma-Ray Dose Measurements. F. W. Spiers. Brit. J. Radiol. **14:** 147–156, May 1941.

The errors in measurement of gamma radiation due to the inverse square law, using small ionization chambers close to a point source of radium, were worked out mathematically. The theoretical values were checked by experiment and show good agreement. Errors for plane distribution of radium were worked out from these formulae giving correction factors for different conditions.

SYDNEY J. HAWLEY, M.D.

Comparison of the Effects of Neutron and Gamma-Ray Ionization on the Electrophoretic Mobility of Colloidal Graphite Particles. L. H. Gray, J. Reed, and H. Liebmann. Brit. J. Radiol. **14:** 102–106, March 1941.

A comparison of the effects of gamma ray and neutron ionization upon the electrophoretic mobility of colloidal graphite shows that while they are qualitatively similar, the neutron ionization is about eight times as effective. The conditions of the experiments are briefly outlined and some of the implications are discussed.

SYDNEY J. HAWLEY, M.D.

EXPERIMENTAL STUDIES

Cutaneous Neoplastic Responses Elicited by Ultraviolet Rays in Hairless Rats and in Their Haired Litter Mates. W. C. Hueper. Cancer Research **1:** 402–406, May 1941.

A back-cross to hereditary hairless rats from the F_1 progeny of hairless by normal animals yielded litters with 20 per cent hairless offspring. The effects of ultraviolet light were tested on haired and hairless litter mates, radiation being administered five times weekly beginning at three to five months of age. The individual exposure was increased gradually from two to sixty minutes. The hairless animals possess normally a hyperkeratotic skin, but succumb more readily to the prolonged treatment. Nevertheless, the carcinogenic action of ultraviolet light was more evident in the haired animals. Of the 20 of the latter type surviving seven months or longer, 18 had single or multiple skin cancers. In 14 animals cutaneous neoplasia was associated with subcutaneous sarcoma. On the other hand, cancer occurred in only 1 of 11 surviving hairless animals, although hypertrophic and atrophic changes in the skin were common in this group. Degeneration and calcification of the arterial media appeared with greater frequency in the haired group. The relationship of the results to the effects of solar radiation in man is discussed.

MILTON J. EISEN, M.D.

X-Ray Skin Reactions and the Protective Rôle of Normal Tissues. B. Jolles. Brit. J. Radiol. **14:** 110–112, March 1941.

Radiation (63 kv., no filter, 125 r per minute, half-value layer 0.025 mm. Cu) was applied to the thighs of rats in circular areas varying from 0.075 to 3.0 cm. The larger areas showed very much greater reactions to equal doses.

The radiation was then given through a grid or screen. Though the skin area and the dose were the same as when a single area was irradiated, the reaction was materially decreased. Even though the dose per unit skin area in these smaller areas was six times that given to one large area, no permanent serious damage was caused.

The author concludes that the presence of a larger amount of normal skin surrounding the area irradiated accounts for this difference.

SYDNEY J. HAWLEY, M.D.